the Petroleum Engineer

FOR MANAGEMENT

INTEGRATED EDITION OF THE PETROLEUM ENGINEER

Ten Aids to Logical Thinking

Is Management for the Specialist?

Russia Makes Slow Progress in "Second Baku"

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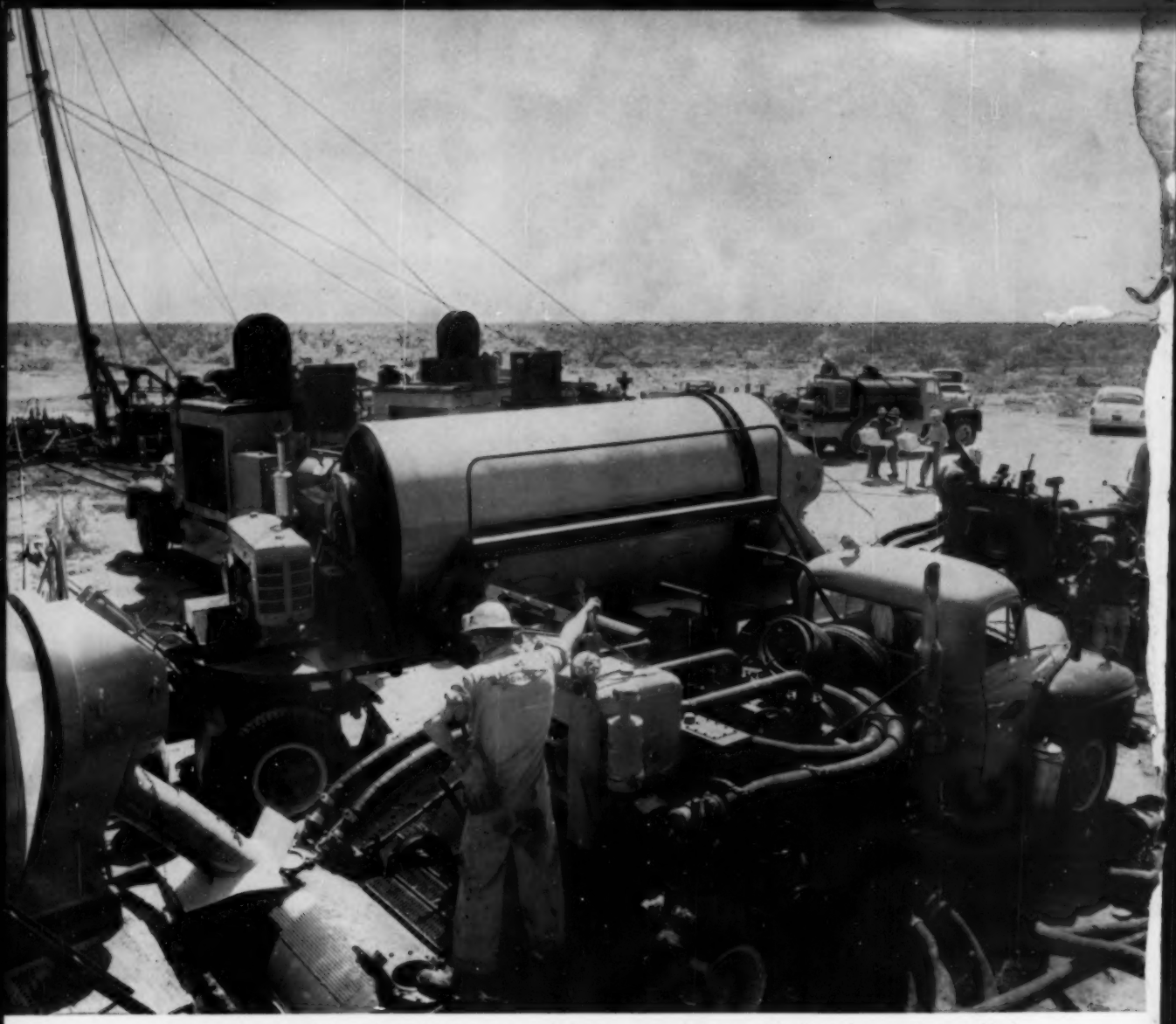

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600 hydraulic h.p. per unit... that's fracturing!

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A Magazine of Petroleum Management

the Petroleum Engineer

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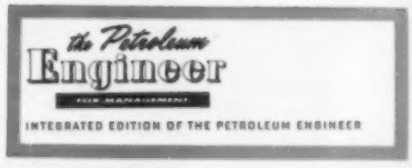

Sanctity of Treaty Sanctity of Contract | Is There a Difference?

Two current events in oil's sphere of activity have had disturbing effects, to state the matter mildly, and could have extremely serious results.

Threatened nationalization of the Suez Canal, definitely the more serious of the two, jeopardizes western Europe's petroleum supply. So great was the danger here as to call for an immediate high level conference of many nations.

Possibly encouraged by Egypt's lead, the Middle East country of Lebanon placed a retroactive tax on two pipe lines that cross its territory — Trans-Arabian Pipe Line and Iraq Pipe Line — in violation of existing contractual agreements.

One of these events raises the question of the sanctity of treaties among nations, the other the sanctity of contracts between national governments and private business.

Although both are recognized as being parallel from a legal and moral standpoint, the sanctity of treaties, seemingly, has always occupied top place in national and international consciousness. The oil industry has been among those to pay through the pocketbook for this kind of thinking. Expropriation and nationalization have struck before, and who can say that the sometimes weakness of governments in failing to back up private business in foreign lands has not opened the door for a part of the present difficulties.

American oil companies have billions of dollars invested in foreign operations now, and expansion in this direction is rapid. All such activities ostensibly are based on binding contractural agreements. If they are not binding, then oil companies operating in foreign countries are in possible danger of losing many millions in investments and profits.

Isn't it important, then, that we begin to look upon the sanctity of contracts in the same light as we do the sanctity of treaties?

Frank H. Love

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We have already had enthusiastic reports that "Oilwell's" new KRōM-I-DEE Subsurface Pump barrel, *lined* with chrome, (left) is giving excellent service in carbon dioxide wells where ringworm-type corrosion has been destructive of previous pumps.

For wells with an excessive carbon dioxide corrosion condition, KRōM-I-DEE barrels with an added external chrome coating (right) are available to bring extra protection to the exterior surface and exposed threads.

Our Neilsen Pump Works has developed a special process that applies a dense, extremely hard, uniform chrome coating to the interior surface of a seamless tube. When this tube has been polish-honed to exact size and is given a high luster finish, it becomes a top quality subsurface pump barrel—KRōM-I-DEE, the best you can use for protection against CO_2 corrosion and abrasive wear.

KRōM-I-DEE barrels cost you only slightly more than the lowest priced pump barrels. They will pay for themselves quickly in fewer pulling jobs.

Write for further information about KRōM-I-DEE, or contact your "Oilwell" or Neilsen representative, or visit your "Oilwell" or Neilsen store.

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Petroleum Profile

AN insatiable desire to do things, a dynamic drive, sense of fair play (and a scrappy rebuttal for foul play) plus a sharp business eye have taken Joe Zeppa, a long way . . . to head of the second largest contract drilling firm in the world . . . Delta Drilling Company and affiliates of Tyler, Texas, now running 55 rotary rigs in the U.S., Venezuela, Italy, Sicily, and North Africa.

The road has not always been smooth for Joe . . . he can look back on 62 years that included some mighty rough going. But, he has a natural ability to fight his way out of any handicap. When he landed in New York in 1906 at the age of 12, he faced learning a new language, a new land . . . and a new challenge, unknown to him back in the small Italian village of Fubine where he was born.

Determined, Joe entered the fifth grade in New York and finished four grades in two years with honors. His early training in the Wall Street law office of Shearman & Sterling provided some of the basic business tools he has since used so well. He started at $3 a week, and in eight years wound up cashier of the firm. In between, at New York University, he studied finance and accounting at nights. He even studied French and international law, and today is well read in art and literature.

Capt. Harry W. Holland, Joe's commanding officer in World War I, brought him to El Dorado, Arkansas, as an accountant during the boom days of 1921. He met Col. T. H. Barton who made him secretary-treasurer of the Natural Gas and Petroleum Corporation. The West lured him, and he joined McMillan Petroleum Company of California to direct sales. Here, he met and married Gertrude Wells Rupple of Pasadena. In September, 1931, he was transferred to Dallas.

With Bob Stacey and Sam Dorfman, who contributed two steam rigs, Joe formed the third side of the triangle of the Delta Drilling Company. Their first well was spudded in December, 1931, in the East Texas field. When Stacey sold out in 1938, Joe acquired more than 60 per cent of the company. He brought in his brother Chris to lend Delta a helping hand . . . and he has been doing that ever since. Today, Chris Zeppa is vice president.

From this turning point on, the story of Joe Zeppa and the story of Delta Drilling Company is nearly one and the same . . . for he has truly lived his business.

Formation of Delta Gulf Drilling Company in 1949 as a subsidiary of Delta Drilling put him in the "big league" of contract drilling. This was accomplished by what was perhaps the most daring business transaction ever consummated in Dallas oil circles at that time. Out of all the negotiations, Delta Drilling was assigned 55 per cent of the interest in the newly-formed Delta Gulf Drilling Company which absorbed the holdings of J. C. Hawkins, prominent independent producer. Included were 22 rigs and some oil production. After the death of Hawkins, the remaining 45 per cent interest was purchased, making Delta Gulf a wholly-owned subsidiary.

JOE ZEPPA, president, Delta Drilling Company

In the fall of 1954, Delta Drilling bought controlling interest in Perforaciones Guarico, C.A., a Venezuelan drilling company, from Allen Finch, who organized it in 1949. Today, it operates 7 rigs. In 1955, he purchased outright 4 rigs from Maracaibo Towing Company in Venezuela, and formed Perforaciones Delta, C.A., a Delta Drilling subsidiary, which now has 6 rigs. Both companies headquarter in Caracas.

His business interests in 1955 turned to his native Italy where, in October, he set up Compagnia Industrie Metanifere E Affini (abbreviated CIMA) as a wholly-owned subsidiary of Delta Drilling. CIMA, with offices in Rome, operates 2 rigs in Italy and 2 rigs are enroute to Sicily.

This year, he wandered further . . . all the way to Libya, in North Africa, where Delta Drilling is working a 11,000-ft rotary. The Zeppa organization is also represented in Spain. Delta Drilling crews operate rigs jointly owned by the Spanish government and a group of Texas oil interests.

Recently, Joe was instrumental in forming Delta Marine Drilling Company in which Delta Drilling has controlling interest. On August 25, the drilling tender "Joseph Zeppa" was christened. Now under construction for Delta Marine is a submersible drilling barge.

Zeppa is vitally concerned with the progress of the American drilling industry which he helped build. Since 1942, Joe has been a director of the American Association of Oilwell Drilling Contractors, and has served on several key committees.

He was instrumental in establishing at Kilgore, Texas, the Kilgore College Drilling Practices Course in 1947 . . . the first of its kind.

In addition to his home in Tyler, Joe takes great pride in his 2200-acre "working" farm 20 miles north of Tyler. His oldest son, Trent and father of Joe's two grandsons, is an attorney for the company. Keating, his youngest boy, is a Navy flier.

It has been said that the Delta organization operates with a minimum of managers for the job it is doing . . . and Joe Zeppa accounts for much of this. He gets up early, stays up late, and every minute between is jam-packed with activity . . . usually his business.

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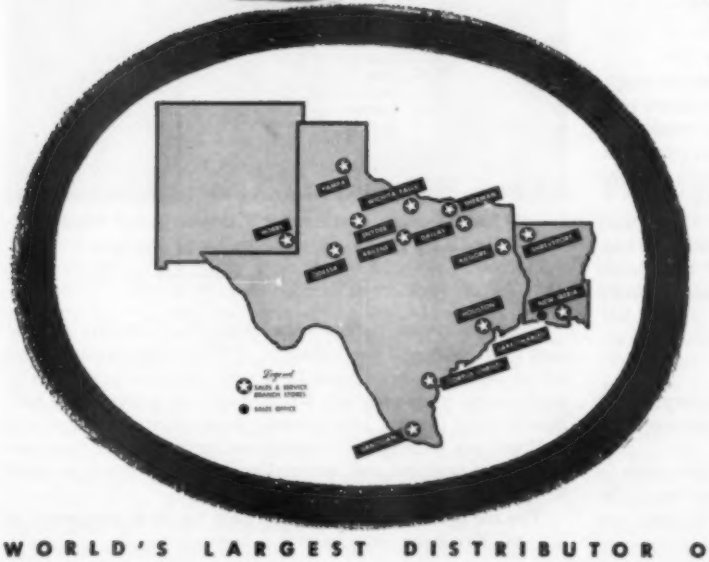
Dependable power by Waukesha engines and first rate, efficient service by Waukesha Sales & Service, Inc., form a partnership that can't be beat. Waukesha Sales & Service, Inc., has completely stocked parts warehouses and repair service facilities located throughout Texas, Louisiana and New Mexico at centers of drilling activity to provide 'round the clock service for your Waukesha engines. So remember Waukesha Sales & Service, Inc., when you want the best in engines and service for your power needs.



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THE CONFERENCE TABLE

"Ask me for anything you like, except time" NAPOLEON

Tomorrow's Management

We talk about developing management but one might almost say that good management is created. More than a year ago George V. Holton, chairman of the board of directors, had this to say about Socony Mobil's approach to good management. We believe it belongs on the Conference Table because it is a simple yet comprehensive statement of managerial development.

"Because corporations need not die, while individuals must, good management is constantly concerned with the selection, training and inspiration of those who are to be management tomorrow. The long-pull investor is as interested in who is coming up in the managerial lineup as in the people on top now. There is no better test of management than its ability to find ever better people to step into its shoes. Good management does not leave this all-important matter to chance, nor does it wait until there is a vacancy to find out whether a replacement is ready and able. Socony Mobil, like many other progressive companies, starts by going after the most promising young people, rather than waiting for them to apply for work.

"To develop people already on the payroll we pay half the tuition for any who wish to improve their education in their free time. One member of our present Board of Directors got his college degree that way. Last year 721 employees took advantage of this plan. On-the-job training programs are available to all. Those who show special promise are systematically moved from one position to another to give them well-rounded experience in our business. A few who seem most likely to benefit by it are sent to universities for advanced management training. This is, of course, entirely apart from scholarships granted our scientists to be advanced work in their special fields.

"The capacity of these managers-to-be is tested not only by assignment to positions of increasing responsibility but also by placing them in charge during occasional absences of top men whose presence is required temporarily in other parts of our world-wide enterprise. No manager at any level is considered to be doing a good job unless his division functions well without him."

What About Small Business?

In the current issue of *Standard Torch*, employee magazine of Standard Oil Company of Indiana, W. H. Scott, purchasing department manager, reveals that his company's dollars go to some 30,000 big, medium, and small suppliers. In his opinion, some bigger companies could take lessons from smaller firms in the service they render.

The last war revealed the mesh of small and middle-size and large companies we need to keep the wheels rolling. And we should keep in mind how dependent upon each other are the various kinds and sizes of business and industry concerns.

What Kind of Specialist?

Do you want your technical men to go into management? Can you afford to let them? Do they make good management material?

These are some questions Gilbert C. Jacobus discusses in the article beginning on Page E-3. Every company has particular problems but this gives a general outline of what you may be facing; if so it will prove enlightening.

Culture and Business

The higher our cultural values the better our business and industry. That is the first and most direct reason why business firms have increased their philanthropy in the last few years. Corporate giving is business' answer to the welfare st[illegible]e. Donald K. David, chairman of the board of trustees of the Ford Foundation said in a recent speech, "In any society business prospers in direct ratio to progress in the cultural, physical, and intellectual well-being of the society as a whole. The development of popular awareness of evolving cultural values in the fine arts, in literature, in music, is good for business.

"The ability of business to produce goods and services, and of the people to consume them, is immediately affected by the level of health in the community. Likewise, production and consumption are affected by the intellectual level of the community, from the achievement of literacy to the development of trade skills and professional techniques."

Russia Fumbles On

Charles L. Adams, who writes for us on the USSR, uses the words of Soviet officials to illuminate the often obscure picture of Russian oil operations. If you want a good look at the present situation, don't skip Page E-13.

Upon Your Vote . . .

"The freeman, casting with unpurchased hand,
The vote that shakes the turret of the land."
Oliver Wendell Holmes

Upon your vote depends the state of our nation for the next four years and the influence of those four years will be felt in all the future. Upon your vote depends your liberty, your career, your progress. Upon your vote depends the welfare of your family, your friends, your country, your world.

If you are willing to let others decide the fate of your economic and political and spiritual well being, there is no need to cast your vote.

The big price has already been paid for your possession of a vote. You have only to pull a lever.

It's Pretty Strong, the Self-Improvement Instinct

When you read about the need for better trained and better educated personnel, you might keep in mind that this is not going against the grain of human inclination. Every man and woman wants to be better than he is. So when the releases about scholarships and education flood over the desk we are hardly surprised. The American Management Association reports this month that nearly 70,000 American, Canadian, and foreign business executives will go back to school this year. The Association's educational program comprises some 700 meetings representing an increase of more than 30 per cent over last year.

In 1956 U. S. industry accepted foreign engineering students for training and American engineering students worked abroad under an exchange project for advanced students of science and technology. This was sponsored by the Institute of International Education.

A practical course in petroleum industry operations for college professors was sponsored by Standard Oil Company of California in San Francisco for the sixth year. The two-week program included conferences with top management and other employees and tours of exploration, producing, transportation, refining, research, and marketing facilities. Purpose of the seminar is to better acquaint the professors with the petroleum industry and to further mutual understanding between educators and businessmen in general.

The Canadian Petroleum Association is distributing a booklet to undergraduates called "Where Are You Going From Here?". Its plea is that university graduates are wanted and needed and that additional years of learning enrich more than the pocketbook. Then the booklet reviews career opportunities in the petroleum industry for those with university training. Included, too, are the entrance requirements for universities in Western Canada. This is good promotion and worth considering in other areas. CPA, Calgary, will supply a sample if you're interested.

Giving equipment is another way of helping schools and we often learn of buildings and laboratories being presented schools by oil companies. A recent instance of this is Cities Service Oil Company's presentation of a truck equipped with reflection-seismograph instruments to the Department of Geology at the University of Colorado.

For 10 years Humble Oil & Refining Company has conducted "Humble Lectures in Science" for technical and research personnel at its Baytown, Texas, refinery. Graduate-level courses have been presented by 41 outstanding authorities from colleges and universities in the United States, Canada, Holland, and Great Britain to groups of employees who enroll on a voluntary basis for the two-weeks sessions.

With the stress on science and technology in all these projects, we can well understand and should respond to the plea of Henderson Supplee, Jr., president of Atlantic Refining, that business management provide its employees with an economic education. He said that rising prices and uneven income improvement had stranded important groups such as farmers and teachers in our economic scene.

He cited the declining trend in use of American tankers as an example of what can happen when costs outstrip productivity. Only three per cent of world tanker tonnage is being built for U. S. ownership.

We agree with Mr. Supplee, economic education is vital.

A Bow for Mr. Burns

Desk and Derrick Clubs end their annual convention with a banquet. The banquet speaker has the serious and difficult task of informing, inspiring, and impressing a sea of industry women who've been going strong for three days, have eaten well, and need sleep. So far the speakers have heroically carried out the assignment and won the interest and applause of their audiences.

In the fifth annual convention last month it looked like a close thing. The New Orleans atmosphere seeped into the banquet room. Instead of soft music there was a Dixieland band that brought on a snake dance, negro tappers, and an hilarious imitation of Elvis Presley.

Mr. H. S. M. Burns, dignified president of Shell Oil Company and speaker at the banquet, was facing 1350 women who were laughing and clapping — thoroughly enjoying the gay entertainment.

"They'll settle down. There's never been an indifferent Desk and Derrick audience," we consoled one of the six men present who was worried that the reaction would be deadly for the speaker.

But they never did settle down. They didn't need to. Mr. Burns threw away his speech, except for spiced excerpts, and kept the brightly dressed audiences in waves of delighted laughter.

Humor is precious and here it was used unsparingly. Real laughter is rare and here it burst forth in abundance. It was a time to remember.

Four Clues to Personnel

Current shortages of skilled help have caused companies to take a second look at their own work forces, seeking four leaf clovers that they've "overlooked before." So says Eugene J. Benge, management engineer and author. "Automation is progressing so fast," Benge says "that we've got to develop skilled men and knowledgeable supervisors—and quick." The new look is in four directions:

1. The search-for-talent, using aptitude tests, supervisory ratings and interviews.

2. Upgrading of technical jobs, to insure that technically trained men are not wasting their talents on clerical or routine duties.

3. Specialized training of skilled workers through *repetitive impact methods,* and following analyses of the knowledge, sensory skills and muscular coordination needed.

4. Key man development, which in addition to normal training, involves improvement of physical factors, social relationships and attitudes, spurred on by both financial and non-financial incentives.

Bibliography of Free Enterprise

Those who know Henry Hazlitt will have confidence in the breadth and accuracy of his new bibliography (*The Free Man's Library,* D. Van Nostrand Company, Inc., Princeton, N. J. $3.50). Over 550 works are classified, each one giving the author, title, publishers, number of pages, date, and a short review. Mr. Hazlitt, who is economic commentator for Newsweek, has included works on free trade, free enterprise and free markets. As the author is a champion of the cause of individual freedom of worship, speech and thought, he has brought deepfelt logic to exorcise the evils of excessive state power. One of the reasons we liked the book is that we agree so wholeheartedly with his statement that Professor Mayet's "The Road to Serfdom" is the most acute and impressive analysis of the modern drift to totalitarianism that has been written in our time.

HIGHLIGHTS ★ ★ ★

Digest of News and Comment

Lack of time and money has made impossible a thorough study of the antitrust aspects of interstate oil and gas compacts, says Attorney General Herbert Brownell. The Justice department, with the money allotted it, compiled 81 pages of what Brownell terms "historical background" and an objection summary of some of the problems of oil production and conservation. The report does not draw any conclusions, and could only "be derived from direct investigation as future budgetary conditions permit," Brownell explained.

★ ★ ★

8,600,000 bbl per day domestic refining capacity has been estimated by the Bureau of Mines in its annual report. In January, 1940, 547 refineries were operating with a combined capacity of 4,000,000 bbl per day. At the end of 1955, only 318 refineries were in operation. At the beginning of the year 326 were in operation. At the beginning of 1956, facilities for processing an additional 267,000 bbl of crude per day were under construction.

★ ★ ★

Sinclair Oil Corporation plans to issue $165,000,000 of new convertible subordinated debentures. A special meeting has been called October 30 to ask stockholders' approval of the major debt financing plan. The operation may be related to recent expansion steps taken by the company to increase oil and gas reserves. Since 1953, date of the last convertible issue, the company has invested more than $570,000,000 in property additions. This amount includes amounts paid for acquisition property owned by American Republics Corporation, Southern Production Company, and a commitment to buy stock owned by Texas Pacific & Coal Company.

★ ★ ★

Army's diesel shortage fears are being met head-on by oil industry officials. Army Secretary Brucker's recent order calling for conversion of diesel equipment be converted to gasoline or "non-petroleum" fuel, is being challenged. Suggestions for offsetting any diesel wartime shortage (doubted by many) include building more refinery flexibility through the fast tax write-off incentive. Diesel engine manufacturers have protested that the new rule will discourage research on compression-ignition engines. Designers of new equipment have been advised that 100-octane gasoline will be available "in quantity." Even the diesel burning tent stove has been affected by the new Army rule.

★ ★ ★

Gas is now the number one fuel for the central heating of American homes, says the American Gas Association. For the first time in central heating history, the fuel has advanced beyond oil heat. Due to the spread of natural gas pipe lines, central gas heating has nearly doubled since 1951. Gas now heats 10,200,000 dwellings, oil heats 10,100,000 and coal heats 7,500,000 homes.

★ ★ ★

Recognition for outstanding cooperation with Armed Forces reservists and reserve activities has been awarded the Magnolia Petroleum Company. The presentation was made in Dallas, Texas, to J. L. Latimer, Magnolia President. Some 200 enlisted men and 30 officers took part in the recognition ceremony. Announcement of the award was made by Defense Secretary Charles E. Wilson.

★ ★ ★

Natural gas pipe line facilities valued at $461,400,000 have been authorized by the Federal Power Commission during the fiscal year ended June 30, 1956. The new facilities, designed to add more than 2,250,000 Mcf of daily delivery capacity to the nation's individual systems, include the construction of 4400 miles of line and about 255,000 hp in compressor units. These figures, calculated by the FPC, include only units for interstate pipe line companies and do not cover certificates issued to independent producers.

★ ★ ★

Formal merger agreement has been made between Panhandle Oil Corporation and American Petrofina, Inc., American Petrofina is the surviving company, and will be a part of the large international oil firm of Compagnie Financiere Belge des Petroles, "Petrofina," S. A. of Belgium. Belgium Petrofina has its principal office in Brussels, Belgium; the new subsidiary has made its office in Dallas, Texas.

Oil industry faces a "market collapse in the near future," warns Standard of Indiana President Frank O. Prior, unless refiners reduce crude oil runs to stills and reduce inventories of gasoline. Prior cited that gasoline stocks are withdrawn at a high rate during this time of the year, with demand waning during the fall months. Although the summer withdrawals have been at a below-seasonal rate, gasoline yield at the refineries have shown but little reduction.

★ ★ ★

Italian government may be asking for too large a share of the net earnings of private oil companies in a new bill making its way through Parliament. The Gulf Italia Oil Company hints that it might quit looking for oil in Italy if the bill is passed. Under the proposed law, the Italian government would take 60 per cent of the net earnings of private firms, in the form of royalties and taxes, say Gulf Italia spokesmen.

★ ★ ★

Engineers and other non-professional writers may learn "polished writing techniques" of professional writers and editors in a new technical writing course beginning October 2 at the Western Technical Writing Institute in Pasadena, California. Among the subjects to be taught are format and presentation of reports and articles, psychological considerations in producing writing efficiency, and the use of composition principles to get coherence, unity, readability, and understanding in technical writing.

★ ★ ★

Oil importers are being asked to reduce fourth-quarter imports by 4 per cent or face government curbs. The oil firms have indicated they plan to import about 385,000 bbl a day during the third quarter, up from the 300,000 bbl per day average during the first six months of 1956. To comply with the new request, these companies will have to slash imports by 95,000 bbl a day. Three times previously this year the Defense Mobilization Office has urged importers to comply with the voluntary program designed to limit imports to the 1954 ratio of foreign to domestic oil. In that year, imported oil made up about 16 per cent of the total oil output.

SEVEN CAT* OILFIELD ENGINES POWER DIXIE'S NEW OFFSHORE RIG

These three D397 Engines power the drawworks for Dixie's offshore rig at Terrebonne Bay.

When Dixie Drilling Co., Houston, Tex., equipped its new offshore rig, it specified seven modern, heavy-duty Caterpillar Oilfield Engines for power. They include three D397s on the drawworks, a D364 on the mud pump, a D337 on the coring line and two D318 Electric Sets.

These four-cycle oilfield engines are ready to work 24 hours a day for years—there are some with over 100,000 hours on their meters! They offer the dependability so necessary in an offshore operation.

And by standardizing on Cat Oilfield Engines, operators and mechanics are familiar with one make of machinery, so they do their jobs faster and easier. Too, parts inventory can be kept low since many parts on these engines are interchangeable.

But more than that, Dixie took advantage of Caterpillar flexibility. There is a wide choice of attachments, giving power tailored to your own special needs. You enjoy a choice of torque converter drive, fluid couplings, or direct drive arranged in the way which helps you do your job best. Air controls and air clutches give you swift, smooth, flexible operation.

And there has been a continual parade of engine and electric set improvements coming from Caterpillar. For instance, the new D337 (Series F) has been turbocharged to produce 310 HP maximum at 2000 RPM. All Cat Engines are offered with a choice of three starting systems—air, electric and gasoline. And there are many other recent advances in this and other Caterpillar Oilfield Engines.

Now is the time to stop in and see your nearby Caterpillar Dealer. He has a full line of new engines and electric sets all designed to save you money, time and trouble.

Caterpillar Tractor Co., Peoria, Illinois, U. S. A.

CATERPILLAR*

*Caterpillar and Cat are Registered Trademarks of Caterpillar Tractor Co.

MODERN HEAVY-DUTY OILFIELD ENGINES

Oil Progress Week observance is just around the corner, advance predictions suggesting this year's celebration to be the biggest yet. To be held October 14 to 20, the API-sponsored week, although primarily conducted on a local level, will feature a nationwide premiere showing of the film, "Destination Earth." Oil shows, association-sponsored events, point-of-purchase promotional giveaways, oil company open houses, speeches, rallies, luncheons, and newspaper special editions will highlight the week's activities.

★ ★ ★

Magnolia Petroleum Company broke ground for its new Duncanville, Texas, research building using seismic charges marking the corners of the structures. The new single-story building will house 21 separate laboratories and 34 offices besides the lab's library and electronic brain. Also included is space for an instrument shop, an electronic shop, and a photo processing room. A second story is planned for construction within the next five years. Completion date for present structure is June, 1957.

★ ★ ★

Soft coal producers say its industry would stand to lose more than $10,000,000 in revenue in the next three years if natural gas distribution is expanded into the Carolinas. The group was heard before an FPC hearing in September on a proposal by three companies to supply 60,000,000 cu ft of gas daily to 40 communities in North and South Carolina.

★ ★ ★

"Riding on air" may be a reality because of a new butyl rubber tire developed by Esso Research and Engineering Company. The new synthetic tire is created entirely from oil refinery gases, and because of its excellent air-holding properties, is being used in making nearly all auto inner tubes. The new tires were made possible through a new process of bonding butyl rubber with tire cord on existing plant equipment, a major scientific achievement. Two Standard affiliates, Esso Standard and Humble, are sole producers of butyl rubber in the U. S.

★ ★ ★

Standard Oil Company (Indiana) has been named one of 10 winners of the *Public Relations News* annual achievement award for its frank and full communication of news arising from the company's Whiting, Indiana, refinery fire last year. Standard's deft handling of news rendered all media in this disaster illustrates that the best interests of a company is served, as well as that of the public, when it gives major attention to its public relations, said the magazine in making the award. Such a policy increased confidence and respect on the part of the company's publics, the press, and the industry.

★ ★ ★

Pipe line route through Turkey is now being surveyed. The line, to be built by Iraq Petroleum Company, would connect Iraq oil production with the Mediterranean. Importance of the action, planned long before the advent of the Suez crisis, is now magnified to a point of international significance. Permission for the reconnaissance was granted by the Turkish government.

★ ★ ★

Colorado Oil & Gas Corporation-Trinidad Petroleum Development Company acquisition agreement follows close on the heels of the Trinidad Oil, Ltd. -Texas Company deal. The two transactions are very similar, except that the Colorado-Trinidad deal will involve the exchange of stock instead of cash. Under the basic agreement, company registration and residence would be changed from Britain to Trinidad for tax purposes, although it would be controlled by U. S. citizens.

Increased government use of helium has demanded addition to the plant at Exell, Texas — now producing beyond its rated capacity. The lighter-than-air gas is extracted from natural gas, and is now used in larger quantities for special projects of the U. S. Government. Interior Department has awarded contract for new construction valued at $1,006,600 for facilities designed to deliver an additional 170,000,000 cu ft of helium yearly. Government, which operates four of the plants, indicated that steadily increasing demand will call for further expansion by 1960.

★ ★ ★

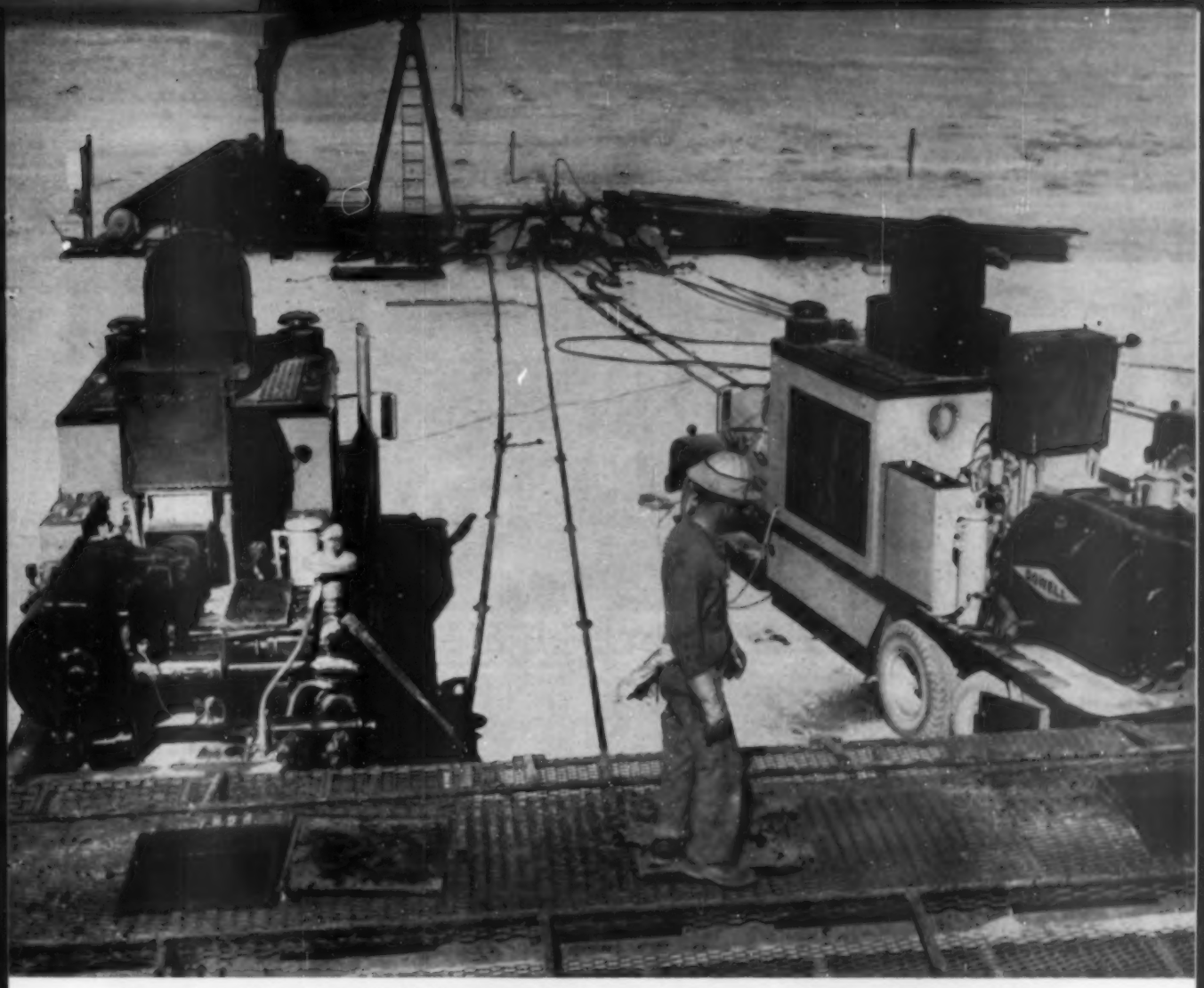
Crude oil purchases and oil runs are being reduced by several companies operating in the Mid-Continent area. Phillips Petroleum will trim its October oil take in Texas, Oklahoma, New Mexico, and Kansas to about 75 per cent of August purchases. Continental Oil Company will reduce its crude runs at its largest refinery in Ponca City, Oklahoma, to about 11 per cent below the August level. Standard Oil Company (Indiana) cut its crude oil runs in September nearly 26,000 bbl per day below operations planned for the same month. Most companies involved attributed the cutback to existing high product inventories among refineries and marketers.

"Whit" Downer Named Associate Refining Editor

S. W. "Whit" Downer this month joined the staff of *The Refining Engineer* as associate editor. He was graduate from Lafayette College, Easton, Pennsylvania, in 1952 with a bachelor of science degree in chemical engineering, and has completed most of the work required for a master's degree in business administration from Rutgers University. For the last four years he has been connected with the East Coast Technical Services Division of Esso Standard Oil Company, making his headquarters at the company's Bayway, New Jersey, refinery.

With Esso Standard he has had a diversified experience in plant operations. In processing this has included principally cat cracking, distillation, wax manufacture, and chemical treating. For a period of a year his primary responsibility

was problems associated with Esso's Underground storage project at Wind Gap, Pennsylvania. Most recently he has been concerned with refining budget planning activities.



Large volumes being delivered by high-horsepower Allison-powered pumping units during an Acid Petrofrac treatment.

Double-acting treatment dissolves while it fractures

ACID PETROFRAC® is a real two-fisted Dowell service for increasing oil and gas production. High acid content and excellent sand carrying ability make it highly effective as a combination acidizing-fracturing treatment.

There are other benefits, too.

You won't be troubled with silicates swelling to plug porosity. Acid Petrofrac has silicate control properties built in. Fluid loss? No problem, either. And, if necessary, you can vary the acid strength to meet specific formation conditions.

Retarded acid action is another natural feature of Acid Petrofrac. Acid Petrofrac fluid, without sand, is even being used as a retarded acid to stimulate production from many problem formations. It is getting results where regular acid treatments have failed.

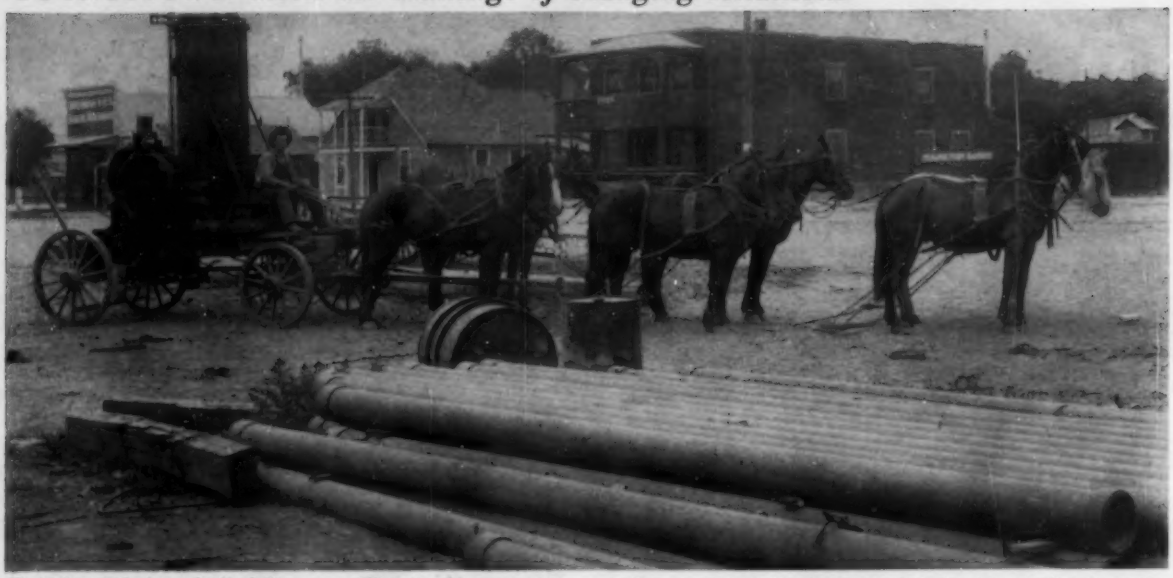
You'll save money with less downtime when you use Acid Petrofrac. Fast breakout and cleanup put your well back on production in a hurry.

For more information or service, call any of the 165 Dowell offices in the United States and Canada; in Venezuela, contact United Oilwell Service. Or write to Dowell Incorporated, Tulsa 1, Oklahoma, Dept. J-12.

services for the oil industry **DOWELL**

A SERVICE SUBSIDIARY OF THE DOW CHEMICAL COMPANY

YOUNGSTOWN meets the challenge of changing conditions



Yesterday—Petroleum in its infancy. . . .When horsepower really meant horses. Bad roads, in addition to limited facilities, made transportation of Oil Field equipment a tremendous job.

Today—Growth of the Petroleum Industry has resulted in vastly improved transportation, storage and handling facilities. Powerful trucks and husky trailers make Oil Field equipment available to the most remote locations.

QUALITY YOUNGSTOWN SERVICE

YOUNGSTOWN OIL COUNTRY TUBULAR GOODS

- Casing—Tubing Drill Pipe
- A full line of types, weights and sizes
- Meets all API specifications
- Satisfactory service in every foot

YOUNGSTOWN KEEPS PACE!

Like transportation, Oil Country Tubular Products have also changed. Old-timers with years of experience know that Youngstown produces Oil Country Tubular Goods to meet the demands of changing conditions and toughest requirements. YOUNGSTOWN has also grown with the Petroleum Industry. Off-shore or on-shore, on the plains or in the mountains, no place is too remote to secure the services of your YOUNGSTOWN representative.

THE YOUNGSTOWN SHEET AND TUBE COMPANY

Manufacturers of Carbon, Alloy and Yoloy Steel

General Offices - Youngstown 1, Ohio

District Sales Offices in Principal Cities

PARADE OF PROGRESS

the
story
behind

TIGER BRAND WIRE ROPE

AMERICAN STEEL & WIRE DIVISION
USS
TRADE MARKS
TIGER BRAND
WIRE ROPE
UNITED STATES STEEL

1831-1956
125
YEARS
PEOPLE · PROGRESS · PRODUCTS

Celebrating our 125th Anniversary

From Hoop Skirts . . . . .to

The first successful wire making enterprise in America was started in 1831 at Worcester, Massachusetts, and became known as Washburn and Moen. This firm produced wire for the woolen industry, for screws and nails and piano wire.

The first big boom in wire making came through a whim in fashion—the hoop skirt—and Washburn and Moen took full advantage of it. They became the leading wire producer in the nation and won a reputation for quality which they never relinquished.

In 1899, during the era of big mergers, Washburn and Moen, along with many other wire making plants, were incorporated into the American Steel and Wire Company of New Jersey, which soon became a part of the United States Steel Corporation.

A few years later, American Steel & Wire began to manufacture wire rope at Trenton, New Jersey and New Haven, Connecticut. This product was highly successful. Production expanded . . . and today American Steel and Wire is the largest producer of wire rope in the world, making more than 1,000 kinds and sizes.

Your closest contact with wire rope may be a daily ride in an elevator. You see it supporting the biggest suspension bridges, and digging coal on mammoth shovels. It is used on the deepest oil wells, on ships and steel mill cranes, for highway guard rails and logging cables. Wire rope and strand are the universal tools for pulling, hauling and transporting man, his goods and materials. Write for our book on Tiger Brand Wire Rope.

AMERICAN STEEL & WIRE DIVISION,
UNITED STATES STEEL CORPORATION, GENERAL OFFICES: CLEVELAND, OHIO

COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO · TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA., SOUTHERN DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS AMERICAN TIGER BRAND WIRE ROPE

Excellay Preformed

Wall of Stainless Steel Strand
Tiger Brand in one of Chicago's new parking garages. American Steel & Wire springs provide the 1,000-lb. tension to keep the strand taut.

Drilling for Oil in the Gulf of Mexico with a new type of rig equipped with 5,000 feet of Tiger Brand Drilling Line.

USS

UNITED STATES STEEL

Suspension Bridges

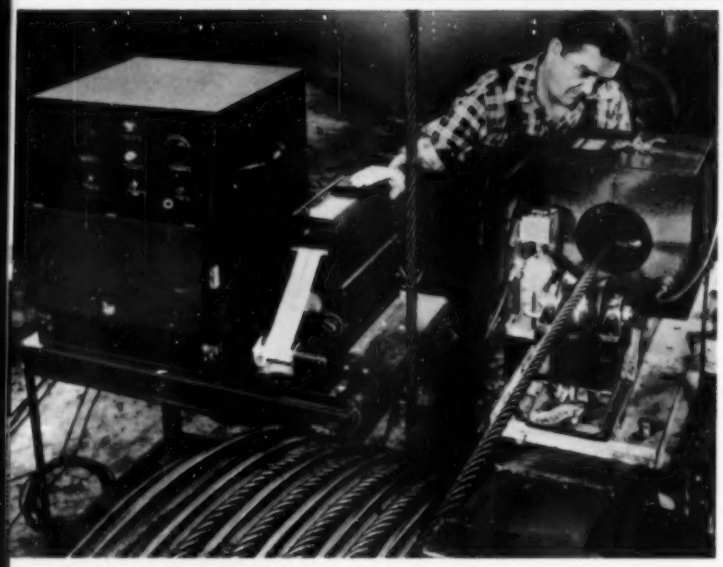
Over 45,000 miles of wire products by American Steel & Wire will be used to complete the Mackinac bridge at St. Ignace, Michigan—longest suspension bridge in the world.

World's Largest Shovel scoops up 60 cubic yards in one bite. Tiger Brand Wire Rope provides the steel "muscles" that make it work.

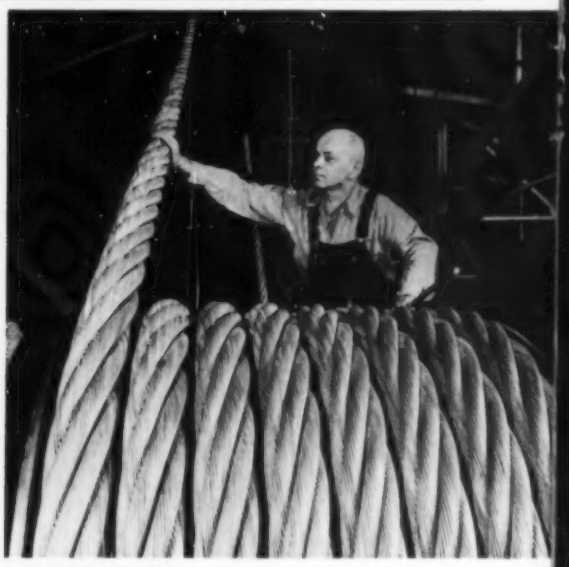
Tall TV Tower for station WGBS-TV in Miami, Florida, must withstand high winds. It is supported by 1⅜" Tiger Brand galvanized strand.

Why Tiger Brand leads . . .

RESEARCH AND ENGINEERING American Steel and Wire has built up one of the finest staffs of wire rope engineers in the country, and in addition can draw from any of the basic research being performed by the United States Steel Corporation. In practice, this means that Tiger Brand Wire Rope is made from the best materials and finest steel being produced. The rope construction is engineered to fit the job . . . and you get a rope that will give the most service at the least cost.



QUALITY CONTROL This means that specified standards of quality are maintained for every step of production from ore to finished product. You can be sure of getting the same high-quality wire rope time after time. The illustration shows an electronic inspection machine, exclusive with American Steel & Wire, that detects if a wire rope imperfection exists, records it on a chart and marks the spot on the rope.



PLANT FACILITIES These are unsurpassed in the industry. American Steel & Wire can make any type and size of wire rope and strand up to the large 4-inch pre-stressed suspension ropes shown here. These ropes are being used on the Pennsylvania-New Jersey Turnpike bridge.

USS AMERICAN TIGER BRAND WIRE ROPE

UNITED STATES STEEL

USS

Meetings

Oct. 1-5—**American Institute of Electrical Engineers,** Morrison Hotel, Chicago, Illinois.

Oct. 2-3—**Texas Mid-Continent Oil & Gas Association,** 37th annual meeting, Rice Hotel, Houston, Texas.

Oct. 2-4—**National Association of Corrosion Engineers,** South central region, Beaumont, Texas.

Oct. 2-6—**Society of Automotive Engineers,** Statler Hotel, Los Angeles, California.

Oct. 7-9—**American Association of Oilwell Drilling Contractors,** 16th annual meeting, Texas Hotel, Fort Worth, Texas.

Oct. 8-10—**ASME-ASLE Lubrication Conference,** Chalfonte-Haddon Hall, Atlantic City, New Jersey.

Oct. 8-12—**American Society for Metals,** 38th annual National Metal Congress and Exposition, Public Auditorium, Cleveland, Ohio.

Oct. 9-10—**Gas Measurement Institute,** 4-H Building, Liberal, Kansas.

Oct. 10-12—**Society of Automotive Engineers,** National transportation meeting, New Yorker Hotel, New York City.

Oct. 11-12—**California Natural Gasoline Association,** fall meeting, Sheraton Huntington Hotel, Pasadena, California.

Oct. 14-16—**Tennessee Oil Men's Association,** fall convention, Hermitage Hotel, Nashville, Tennessee.

Oct. 14-17—**American Institute of Mining, Metallurgical and Petroleum Engineers,** fall meeting, Biltmore Hotel, Los Angeles, California.

Oct. 15-17—**American Gas Association,** annual meeting, Atlantic City, New Jersey.

Oct. 15-19—**American Society of Civil Engineers,** annual convention, William Penn Hotel, Pittsburgh, Pennsylvania.

Oct. 17-18—**Indiana Independent Petroleum Association,** Severin Hotel, Indianapolis, Indiana.

Oct. 18—**West Virginia Petroleum Association,** 19th annual convention, Daniel Boone Hotel, Charleston, West Virginia.

Oct. 18-19—**Western Petroleum Refiners Association,** regional technical-industrial relations meeting. Rufus Garrett Hotel, El Dorado, Arkansas.

Oct. 18-21. **Permian Basin Oil Show,** Odessa, Texas.

Oct. 22-24—**American Standards Association,** 7th national conference, Roosevelt Hotel, New York City.

Oct. 22-24—**National Lubricating Grease Institute,** annual meeting, Edgewater Beach Hotel, Chicago, Illinois.

Oct. 22-24—**Rocky Mountain Oil & Gas Association,** annual meeting, Cosmopolitan Hotel, Denver, Colorado.

Oct. 23—**American Society of Safety Engineers,** annual meeting, Conrad Hilton Hotel, Chicago, Illinois.

Oct. 23-26- -**National Association of Corrosion Engineers,** annual south central region meeting, San Antonio, Texas.

Use low-cost

CONCENTRATED

BORASCU®

WEED KILLER

wherever weeds and grasses are a FIRE HAZARD!

Your "grassing" costs can drop as much as 80% when you use this weed killer! Savings in man-hours alone can be impressive when you consider that year-long results come from just one easy, DRY application of powerful Concentrated BORASCU. This granular, inorganic herbicide **destroys** most vegetation and **prevents regrowth** for long periods because it **remains active** in the root zone; satisfactorily meets all your requirements for safety.

NOTHING TO MIX

NO WATER TO HAUL

NONPOISONOUS

NONCORROSIVE TO FERROUS METALS

Want details? Write... **United States Borax & Chemical Corporation**

PACIFIC COAST BORAX COMPANY DIVISION

630 SHATTO PLACE, LOS ANGELES 5, CALIFORNIA

DISTRIBUTORS LOCATED THROUGHOUT OIL FIELDS OF U.S.A., CANADA, MEXICO, COLOMBIA, VENEZUELA.

Photo by Jerry Pratt, Constructioneer

Gorman-Rupp Drainage Pump KEEPS PENNA. DAM JOB MOVING

Seepage on construction near Spring Grove, Penna., is quickly removed by a Gorman-Rupp 90M Pump, Model 3602, letting work proceed on the removal of solid rock. The pump stands about 20 feet above water level and is discharging over the rise as shown in the upper right of the picture. The 500-ft. spillway chute handles overflow from the 2½-sq.-mi. dam.

Dewatering problems encountered on this job are identical to those in pipeline construction. Put Gorman-Rupp on the job before you have trouble. Our plain-language guarantee is backed by a long record of proved performance on the job.

Send coupon below to our Mid-Continent & Gulf Coast Oilfield Representative for the 24-page Gorman-Rupp Oilfield Catalog. It describes the many models of Gorman-Rupp Pumps useful in your business. The Gorman-Rupp Company, 305 Bowman Street, Mansfield, Ohio.

FREE!

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1125 Rothwell St., Houston, Texas
Please send me the Gorman-Rupp Oilfield Catalog

NAME_____
ADDRESS_____
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CITY_____ STATE_____

Oct. 25-26—**Independent Petroleum Association of America,** annual membership, Mayo Hotel, Tulsa, Oklahoma.

Oct. 28-30—**American Petroleum Association of America,** annual meeting, Statler Hilton Hotel, Dallas, Texas.

Oct. 29-30—**Petroleum Engineering Conference on Water Flooding,** sponsored by Illinois State Geological Survey, on the University of Illinois Campus, Urbana, Illinois.

Oct. 29-30—**Independent Petroleum Association of America,** 27th annual meeting, Statler Hilton Hotel, Dallas, Texas.

Oct. 29-Nov. 1—**Society of Exploration Geophysicists,** national convention, Roosevelt Hotel, New Orleans, Louisiana.

Oct. 31-Nov. 2—**Gulf Coast Association of Geological Societies,** 6th annual convention, Plaza Hotel, San Antonio, Texas.

Nov. 1-2—**Louisiana Polytechnic Institute,** School of Engineering, 5th annual Instrumentation Conference, on campus, Ruston, Louisiana.

Nov. 7-10—**SAMA Laboratory Apparatus and Optical Sections,** midyear meeting, The Homestead, Hot Springs, Virginia.

Nov. 8-9—**National Association of Corrosion Engineers,** southeast region meeting, Charlotte, North Carolina.

Nov. 12-15—**American Petroleum Institute,** 36th annual meeting, Conrad Hilton Hotel and Palmer House, Chicago, Illinois.

Nov. 19-20—**North Texas Secondary Recovery Symposium,** Petroleum branch, AIME, Municipal Auditorium, Wichita Falls, Texas.

Nov. 25-30—**American Society of Mechanical Engineers,** Statler Hotel, New York City.

Nov. 26-30—**Third International Automation Exposition,** Trade Show Building, New York City.

Nov. 27-30—**National Chemical Exposition,** 9th trade show, Cleveland Public Auditorium, Cleveland, Ohio.

Dec. 9-12—**American Institute of Chemical Engineers,** annual meeting, Statler Hotel, Boston, Massachusetts.

1957

Jan. 14-16—**Pipe Line Contractors Association,** Boca Raton Hotel and Club, Boca Raton, Florida.

Jan. 28-31—**Plant Maintenance and Engineering Show,** Public Auditorium, Cleveland, Ohio.

Feb. 24-28—**American Institute of Mining, Metallurgical, and Petroleum Engineers,** Annual meeting, Hotels Roosevelt and Jung, New Orleans, Louisiana.

April 24-26—**Natural Gasoline Association of America,** 36th annual convention, Rice Hotel, Houston, Texas.

Oct. 9-10—**Third Annual Computer Applications Symposium,** sponsored by Armour Research Foundation of Illinois Institute of Technology, Morrison Hotel, Chicago, Illinois.

Nov. 30-Dec. 1—**Executive Committee of Interstate Oil Compact Commission,** Wichita, Kansas.

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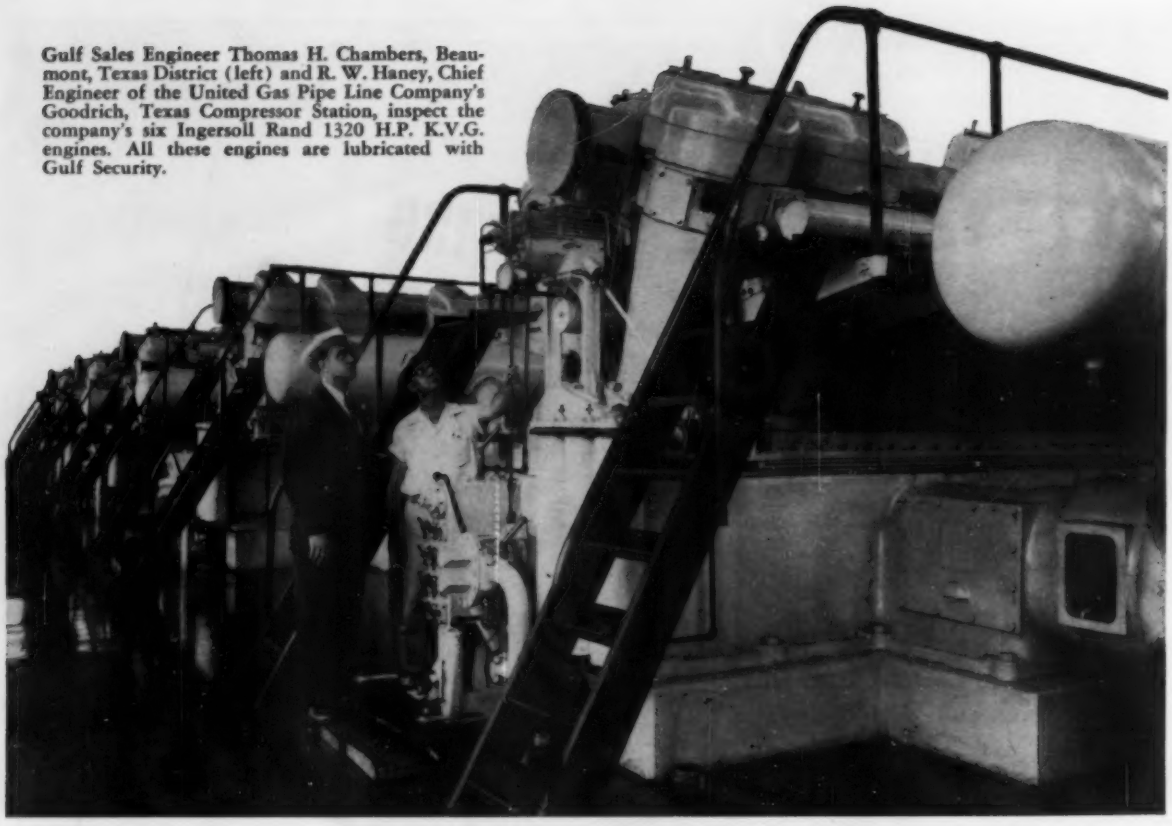
SETTING
NEW STANDARDS
OF PERFORMANCE...
Another
LUNKENHEIMER
FIRST!
THE
LQ600
VALVE
FIG. LQ600-200
200 lb. S.P.—400 lb. W.O.G.
550° F.
FIG. LQ600-150
150 lb. S.P.—300 lb. W.O.G.
¼ to 2 inches
Thousands of these valves have served for as long as five years without replacement, regrinding, maintenance, or leakage—even on the most severe services. Their patented Brinalloy* seats and discs are more resistant to wear and corrosion than 500 Brinell Stainless Steel . . . even outlast case-hardened Stainless Steel exceeding 1000 Brinell. LQ600 Valves practically eliminate maintenance costs!
*Patented Alloy—T. M. Reg.
SEE YOUR LUNKENHEIMER DISTRIBUTOR
or write for literature
THE LUNKENHEIMER CO., CINCINNATI 14, OHIO
LUNKENHEIMER®
THE ONE Great NAME IN VALVES
L-456-28



Gulf Sales Engineer Thomas H. Chambers, Beaumont, Texas District (left) and R. W. Haney, Chief Engineer of the United Gas Pipe Line Company's Goodrich, Texas Compressor Station, inspect the company's six Ingersoll Rand 1320 H.P. K.V.G. engines. All these engines are lubricated with Gulf Security.

Lock out high maintenance costs in your gas transmission plants

with GULF SECURITY

Gulf Security's outstanding record in the lubrication of pipeline gas engine compressor units is your assurance of smooth, continuous operation. In scores of gas transmission plants this high quality straight mineral oil helps prevent operating troubles and contributes to low maintenance costs.

Gulf Security is a non-additive oil that does not cloud liquid filled lubricators of power cylinders, compressor cylinders, and packing glands. After years of operation with Gulf Security, cylinders and piston rings of both compressors and power assemblies show negligible wear, and its excellent oxidation stability helps prevent the formation of acid and resins in the crankcase system.

Make certain your units receive safe, effective lubrication protection—specify Gulf Security. And remember that Gulf provides the services of a trained, experienced petroleum expert—the Gulf Sales Engineer—to help you with any problem involving a petroleum product. Consult the telephone directory for the number of your nearest Gulf office.

GULF

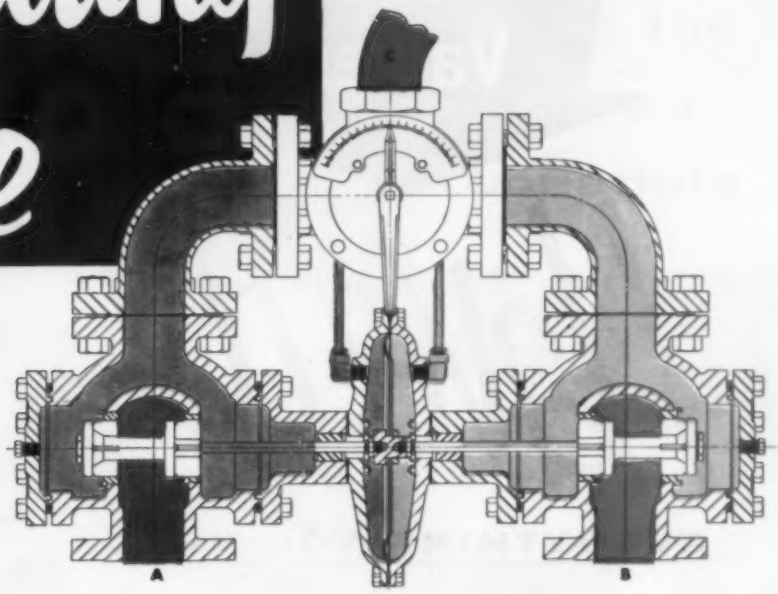
Gulf Oil Corporation • Gulf Refining Company
1822 Gulf Building, Pittsburgh 30, Pa.

THE FINEST PETROLEUM PRODUCTS FOR ALL YOUR NEEDS

FISHER®

Blending Valve

AUTOMATICALLY BLENDS TWO FLUIDS IN ACCURATE DESIRED PROPORTIONS



LEGEND

- FLUID A — Fluctuating Inlet Pressure
- FLUID B — Fluctuating Inlet Pressure
- FLUID A — Constant Equalized Reduced Pressure
- FLUID B — Constant Equalized Reduced Pressure
- FLUID C — Blended Fluid of Desired Characteristics

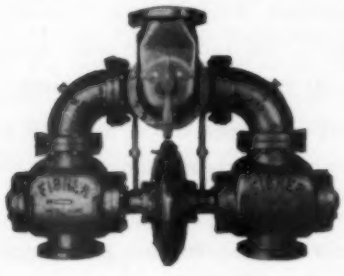
- **Eliminates necessity of measuring given quantities and batch agitation.**
- **No vapor loss in gasoline blending.**
- **Reduces blending process expense.**
- **Pointer and scale device affords simple method of accurately controlling percentages of inlet fluids to be blended.**
- **Successfully used for over 10 years.**

SPECIFICATIONS

Sizes Available—3" and 6" flanged iron or steel.

Capacities—30 to 900 gpm— 3" $C_v = 84$; 6" $C_v = 275$

Accuracy—± 1%—Pressure rating 100 psi.



The Fisher Type 430 Blending Valve will accurately blend two liquids in any proportion, holding the blend ratio constant and independent of variation in pumping pressure by action of the equalizing pressure regulator. It is suitable for blending any fluids of moderate viscosity which do not carry suspended solids and which flow at relatively constant temperature. A great number have been installed in refineries and bulk plants for blending different grades of gasoline to obtain a higher octane grade.

The blending unit employs the principle of parallel metering of the fluids through two orifices whose rates of area may be varied, while at the same time holding the pressure drop across the orifices at the same value. Thus, the ratio of the two orifices areas is in direct proportion to the bleed or ratio of the two flowing streams.

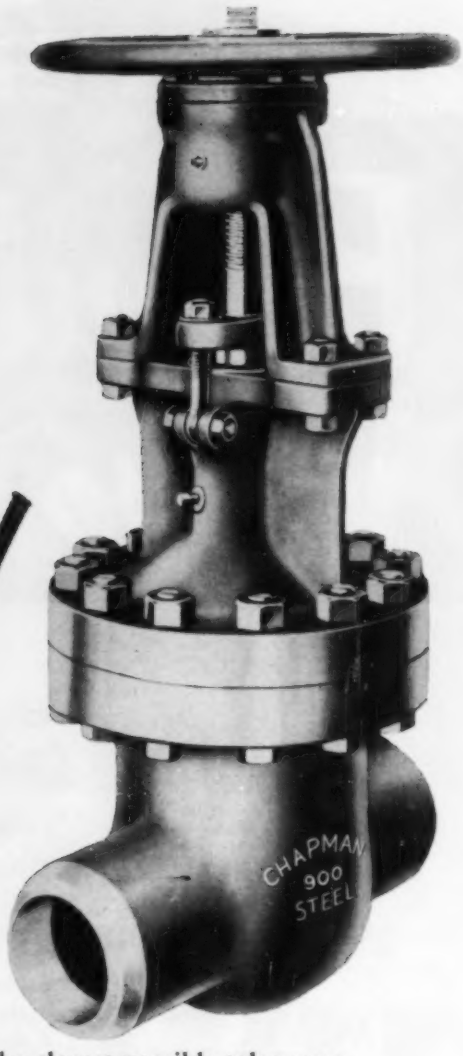
FISHER GOVERNOR COMPANY
MARSHALLTOWN, IOWA • WOODSTOCK, ONTARIO

LEADS THE INDUSTRY IN RESEARCH FOR BETTER PRESSURE AND LIQUID LEVEL CONTROL

FISHER Since 1880

Chapman Steel Valves

Have It!



EVERYTHING YOU NEED

You want steel valves that will prove their metal under tough and varied conditions.

Chapman has them. Steel valves . . . in many different alloys . . . all carefully formulated and poured under rigid supervision in Chapman's own foundry.

You want steel valves with the smoothest operation for years of rugged service.

Again, Chapman has them. Valves that seat tightly, accurately, permanently. Valves that don't jam, chatter or wear excessively. Valves with the closest possible tolerances.

Just name your steel valve requirements. Pressure and temperature for any specified operating condition are met as you want them with Chapman Steel Valves. This includes Chapman welded, pressure seal, bolted bonnet, or valves of special design.

They all equal or exceed A.S.A. and A.P.I. standards. They all cut maintenance costs to a new low.

For your own sake and convenience, get a copy of Chapman Catalog 20 now.

THE CHAPMAN VALVE MANUFACTURING CO.

INDIAN ORCHARD, MASSACHUSETTS

Hardpan, sand or rice fields...

MD7s keep the pipe on schedule

In the 21-mile stretch between North Sacramento Valley and Sacramento in California, the terrain includes volcanic hardpan, sand and rice fields. In this stretch, Underground Construction Co. and Stolte, Inc., used three CAT* MD7 Pipelayers to lay a 16-inch steel gas line at the rate of ½ mile a day.

No matter how rough the going, the new Caterpillar MD7 Pipelayer is designed to provide extra flotation and stability. For it has available non-oscillating seven-roller track frames and 22" track shoes which give 4840 square inches of ground contact.

Lifting capacity is 54,200 lb. maximum. Its dependable Cat Diesel Engine puts 128 HP at your disposal. And like all Cat Engines, it can idle for hours without fouling.

But most important, this unit was designed to give you long, productive life. The exclusive oil clutch is almost completely free of time-wasting and costly adjustment and repairs. Power-boosted steering clutches and quick reversing transmission speed your job. Convenient hydraulic controls permit quick adjustment of the counterweight rack. The 18-foot boom gives enough reach to help avoid cave-ins.

You can start increasing your work speed and profits immediately. Call your nearby Caterpillar Dealer. He will demonstrate the new, improved MD7 at your convenience on *your* job.

Caterpillar Tractor Co., Peoria, Illinois, U. S. A.

CATERPILLAR*

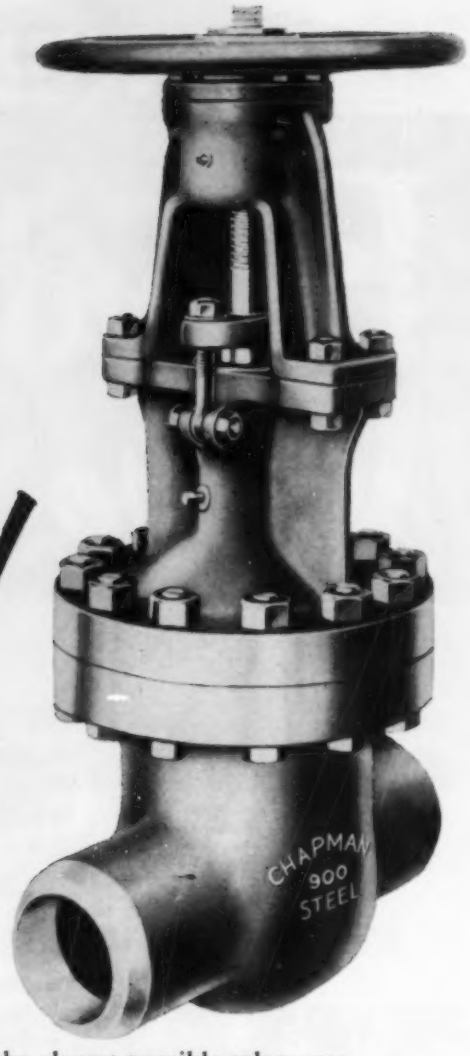
*Caterpillar and Cat are Registered Trademarks of Caterpillar Tractor Co.

NAME THE DATE... YOUR DEALER WILL DEMONSTRATE

Chapman Steel Valves

Have It!

EVERYTHING YOU NEED



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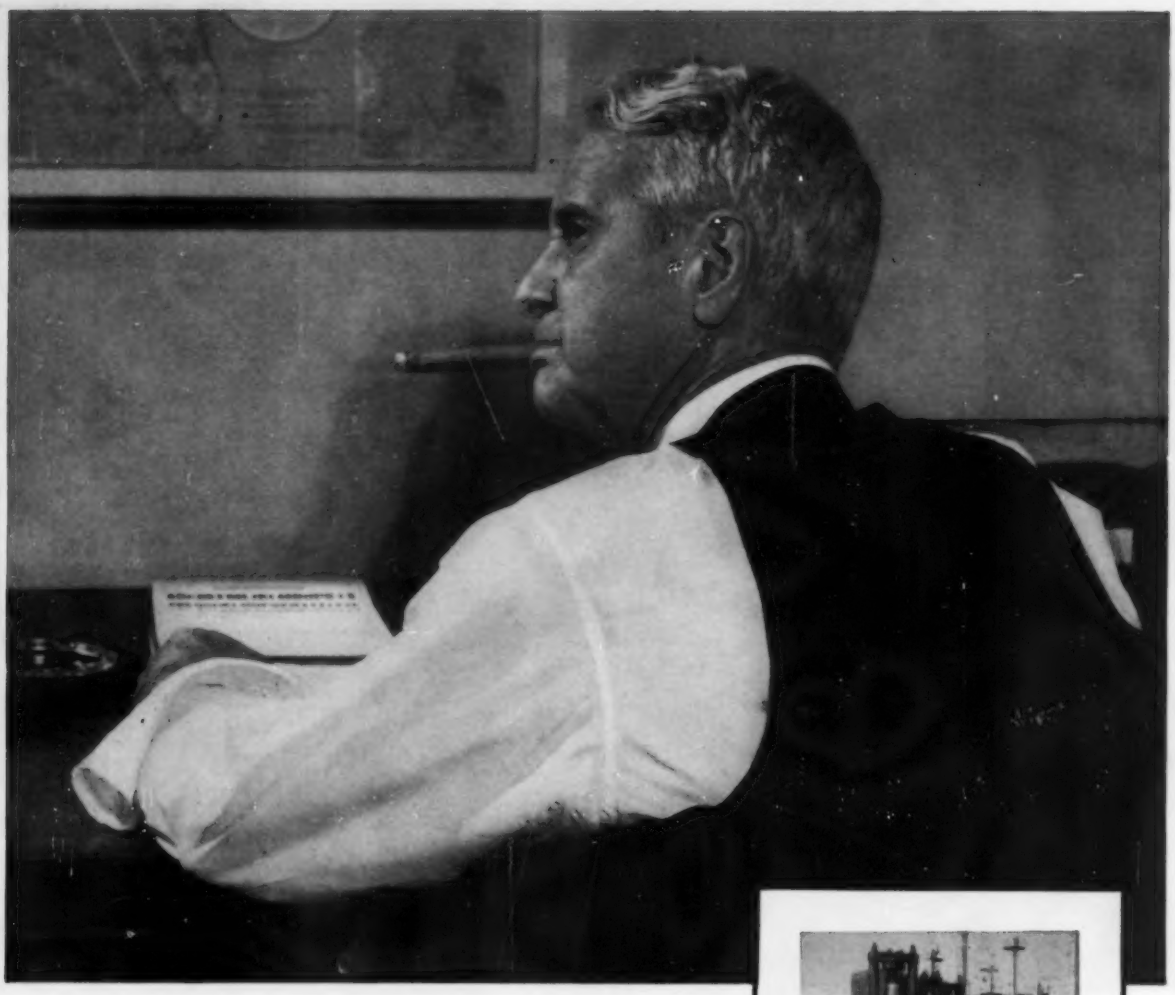

"And I say it has to be an ALDRICH PUMP!"

Continuous, heavy duty pumping operations, often at high pressures, demand the complete reliability and freedom from maintenance found only in an Aldrich Pump. Top performance under these conditions has earned Aldrich its reputation for building pumps of highest quality and dependability.

The tougher the job . . . the more important it becomes to take advantage of our wide experience in providing the petroleum industry with pumps for water flood, pipeline, gasoline plant, hydrocarbon injection or petrochemical service.

In the less critical jobs, too . . . it makes sense to call Aldrich. The simplicity of the Aldrich Direct Flow design, with fluid-end sectionalization and automatically controlled delivery, offers substantial economies in both operation and maintenance.

A copy of our new condensed catalog, showing the line of Aldrich Pumps is yours for the asking. Write for Data Sheet 100. The Aldrich Pump Company, 26 Pine Street, Allentown, Pa.

Shown above is one of a number of Aldrich 5" stroke, Triplex Pumps installed at a major west coast water injection project. These pumps are currently handling 35,000 bbl daily at injection pressures of 1,000 psi.

THE ALDRICH PUMP COMPANY

the Mid-Continent Supply Company

MACHINERY MAN

His job is to Serve you!

A staff of experienced machinery men is at your service when you order oil field equipment from Mid-Continent Supply Company. Their job is to serve you, to aid you in selecting equipment best suited to your requirements.

In rigging up your new equipment, Mid-Continent's Machinery Department engineering service and field supervision help assure money-saving drilling operation.

For a single item or a complete drilling rig "package", it pays to call Mid-Continent.

MID-CONTINENT Supply Company

MID-CONTINENT BLDG. • FORT WORTH, TEXAS

THE WORLD'S LARGEST INDEPENDENT OIL FIELD SUPPLY COMPANY

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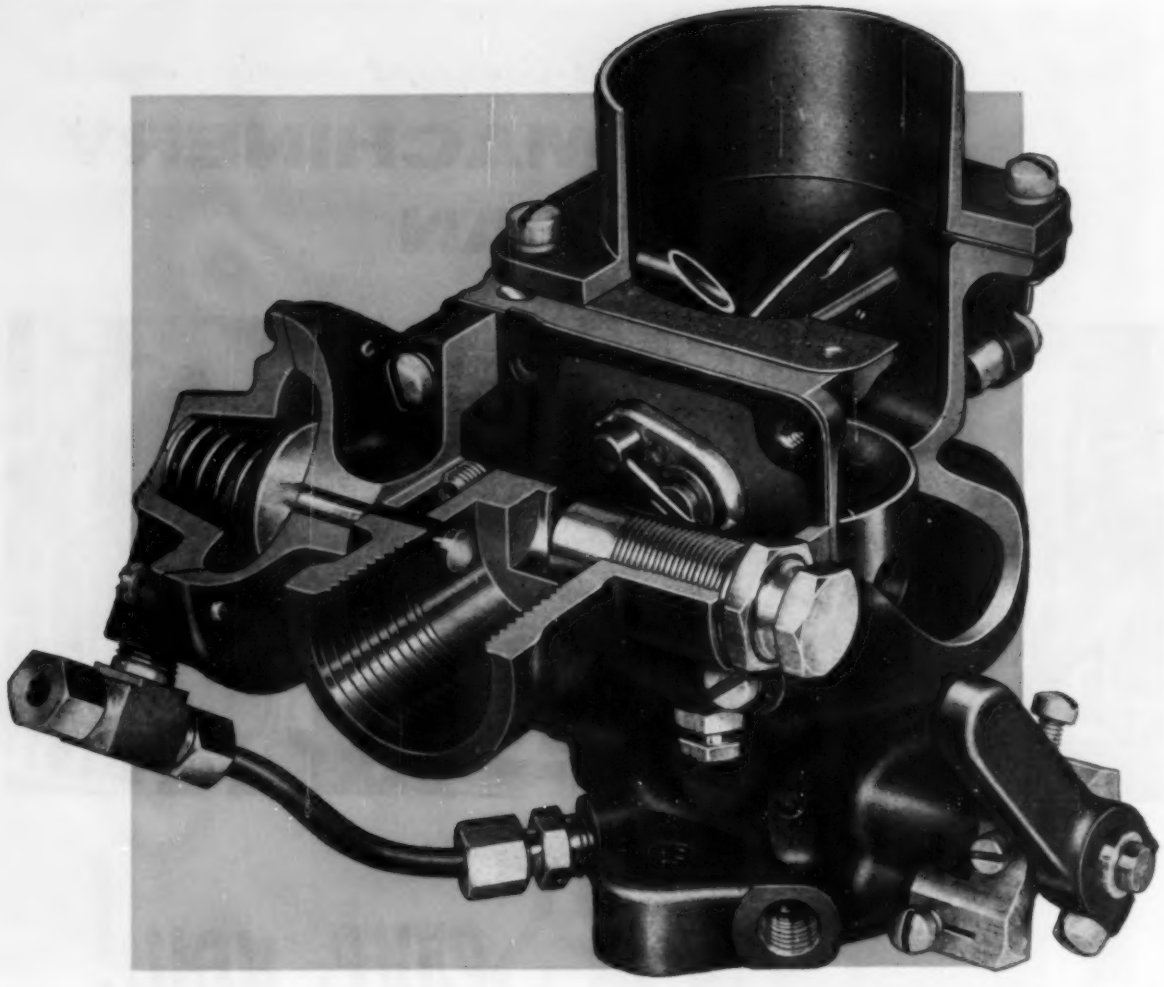

On America's finest gas engines... ENSIGN

Model Xg in Up-Draft position showing air cleaner elbow.

- Built-in fixed orifice economizer.
- Instant starting. Utilizes separate set of adjustable gas-air orifices.
- Provisions for balancing air-fuel ratios against air entrance losses.
- Interchange venturi to meet wide range of engine operating conditions.
- Made in 1¼, 1½, 1¾ and 2" SAE Sizes.

Pictured here is the culmination of 45 years of carburetor experience—ENSIGN'S Model Xg Gas Carburetor for Natural and LP-Gas engines.

Every part of this carburetor—every contour is carefully designed to achieve certain results, the combination of which spells Easy Starting, Rapid Acceleration, Smooth Idle, Full Power and Economy. But most important, is the ability of this carburetor to perform consistently throughout the entire life of the engine. DEPENDABILITY—that's what the name ENSIGN on a carburetor stands for. Insist on ENSIGN—accept nothing less.

For complete details of all Ensign equipment send for Catalog #108.

ENSIGN CARBURETOR COMPANY

1551 E. Orangethorpe, Fullerton, California
Branch Factory: 2330 W. 58th Street, Chicago, Illinois

1 in 1940

today... **1425** in operation

and **75** more under construction

a record of installations that is incomparable
just as all Petrochem-Isoflow Furnaces
are more economically desirable by any comparison.

PETROCHEM-ISOFLOW FURNACES

UNLIMITED IN SIZE ... CAPACITY ... DUTY

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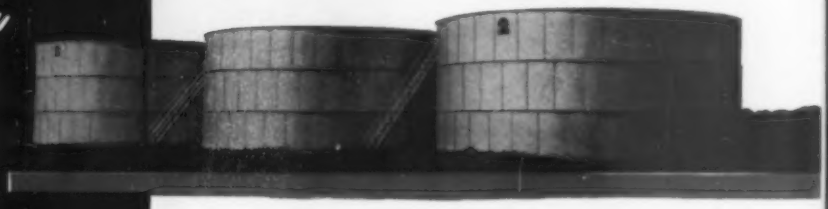
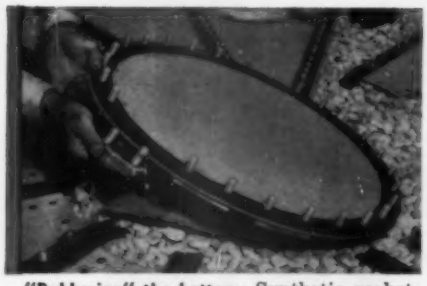
You have a place at every operation too! All of us oilmen—from exploration men like me to whatever you are—played an important part in the 9,131,545 surgical operations performed last year. We helped supply the doctors with germicides, anesthetics, antibiotics and many of the surgical accessories that help save lives. Unfortunately, too few outsiders know how much oilmen contribute to the health and happiness of the people. Are you doing everything you can to spread the word? It's to your advantage to have your industry understood and appreciated. **SHELL OIL COMPANY**

Here's Why COLUMBIAN BOLTED STEEL TANKS "Just Fit Up Better"

For more than 60 years Columbian steel tanks have been the standard for tank tightness and lasting quality. Why do Columbians "just fit up better"? There are many reasons. First of all, the high-precision machinery Columbian uses in forming and punching the tank plates and decks . . . and the master-craftsmen in steel who operate those modern machines. But beyond that, it's the attention given to assuring the tight seal of every joint and seam when a Columbian tank is fabricated. The pictures here show how easy it is for a crew to fit up a tight tank — when it's a Columbian.



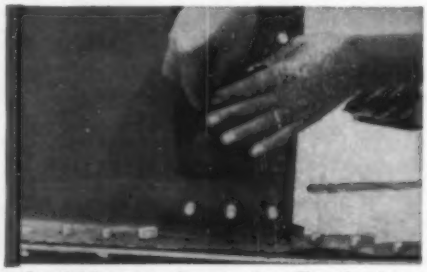


"Rubbering" the bottom: Synthetic gasket material is applied to center plate of Columbian tank bottom. Note short channel lengths for holding bolt heads.

Joining bottom segments: "Rubbered" on one edge and bolted to adjoining segments. Special wedge-shaped gaskets are provided for three-thickness (2 segments and center plate) joints.

Tight-Sealed bolt holes: Steel backed Neoprene washers are provided for all side and bottom seams. As bolts are tightened cup-shaped steel washers press rubber washers tight in and around bolt holes, forming a perfect, leak-proof seal.

Leak-proof Side-Bottom seam: The special wedge-shaped gasket is used for joints of 3 thicknesses (bottom and lap of 2 staves). To prevent any possible leak at flange radius, a special radius gasket—a Columbian extra—is inserted under stave's strip gasket.



Special Large-tank protection: For the double or triple bolt rows on large-capacity tanks, Columbian provides not only strip gaskets for each row but the special radius gaskets to span each row of holes.

No leak out at cleanout: Cover (either flat or extended) for cleanout is sealed tightly to stave. Strip gaskets extend beyond corner bolts with tank cement under laps of side and top gasket strips. Special radius gaskets are used under side strip gaskets at bottom flange.

Want to Know ALL About Columbian Tanks?

COLUMBIAN'S new BOLTED TANK CATALOG is more than just a catalog — it gives you the full story of tank construction in pictures . . . shows you the many ways Columbian bolted Steel Tanks are being used for crude and refined storage . . . in the oil fields . . . by communities and industries all over the world.

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TANKS FOR THE WORLD

T. M. Reg.

A STERN VIEW
of
Petroleum Progress

Though it dwarfs the once mighty tankers of ten years ago, this huge Cities Service super tanker may some day be dwarfed itself. That is the enigma of size and the essence of progress . . . the reason why we constantly strive to better our works, no matter how great they seem to ourselves.

In this light, Cities Service views its current record: The all-time high in petroleum production . . . the one-out-of-three success ratio in test well drilling—far above the ratio for the industry . . . the new peak in stockholders' equity . . . and the soaring sales of Cities Service petroleum products.

The significance of these accomplishments lies not so much in what they are as in what they precede . . . for they set the pattern of bigger and better things to come from Cities Service.

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BRONZE TRIM FIG. 333

Both of these OIC Duo-Bolt gates have special stems. The Fig. 333 stem is OIC *Alloy-40* in sizes 2″ and under . . . corrosion-resistant bronze with 20 to 30 times longer life than most other stem bronzes. It will not gall or seize. In fact, this alloy has all but eliminated stem replacement. The Fig. 337 stem is nickel-plated steel . . . highly resistant to pitting in the packing area, sturdy and long wearing.

Design includes bonnet drain ducts . . . recessed gasket seat

To protect against freezing, bonnet ducts allow complete drainage of the upper part of the valve. The male-female, gasketed body-bonnet connection assures a tight joint and prevents blown gaskets.

Exclusive cast-in seat rings

On sizes 2″ and under, bronze trimmed valves include cast-in seat rings, *rolled* to make doubly sure that they cannot loosen in service. On sizes 2½″ and larger, seat rings are screwed in. Seats are integral on all-iron trim valves. Both types include a button-head stem-to-wedge connection, flexible for non-binding wedge seating.

Immediate availability . . . long line

Order Duo-Bolt gates from your OIC Distributor or his field store. Sizes: ¼″ to 4″, screwed or flanged ends. Working pressures: 125 to 150 lbs. WSP, 200 to 225 lbs. cold WOG, non-shock. Request Form No. 1007 for more information.

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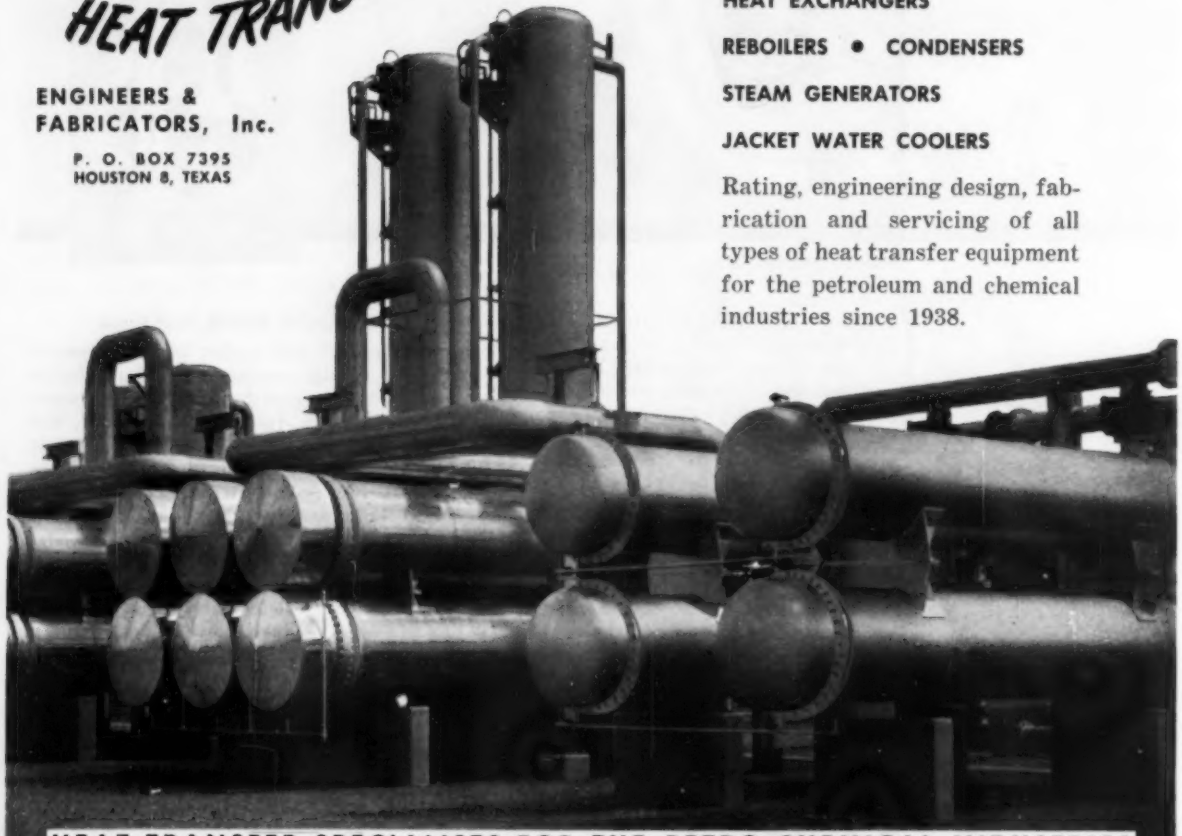

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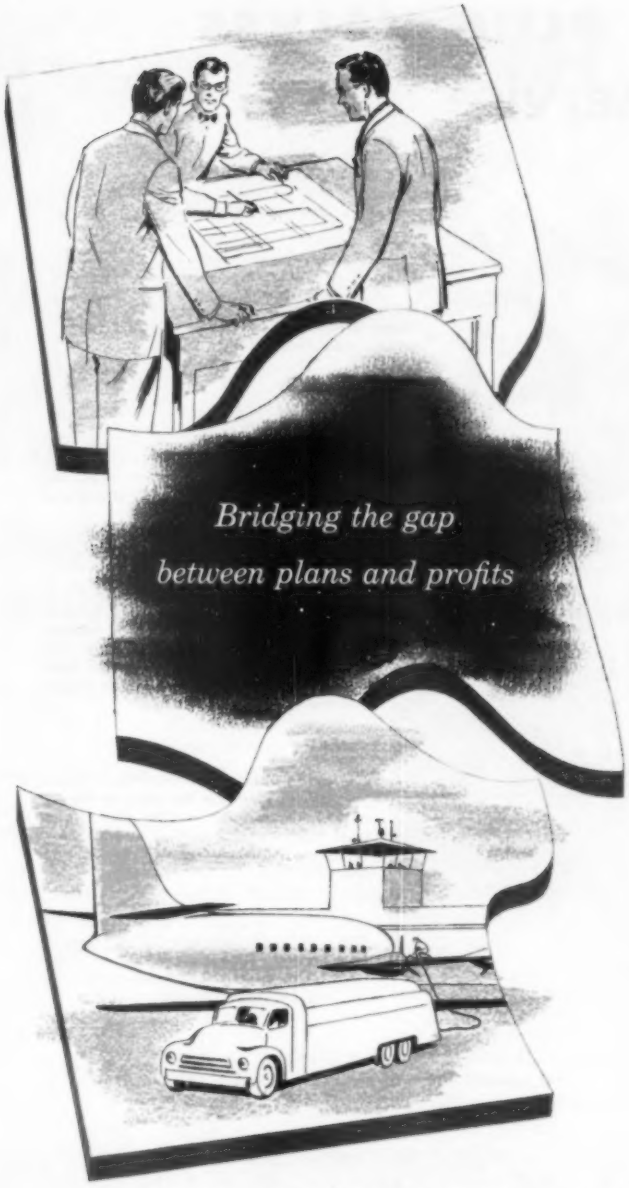

WORLD'S LARGEST SOVAFORMER...

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Socony-Mobil Oil Company, Inc. now owns the largest commercial Sovaformer ever built. This giant unit, rated at 20,000 barrels-per-stream-day, produces high octane motor fuel and aviation gasoline to meet the increasing demands of today's high compression engines.

The project—with a construction period of only 12 months—is another example of how The Fluor Corporation, Ltd. swiftly turns management planning into profitable production. Whether your plans call for a complete processing plant or a single unit, it will pay you to get acquainted with Fluor.

The Sovaformer covers an area of 120,000 square feet. Consisting of a catalytic reformer section and a naphtha pretreater section, the Sovaformer was Fluor's second multi-million dollar project completed at Socony Mobil's Paulsboro, New Jersey refinery in the past three years.

FLUOR *ENGINEERS and CONSTRUCTORS*
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Let's get technical about WALWORTH LUBRICATED PLUG VALVES for pipeline service

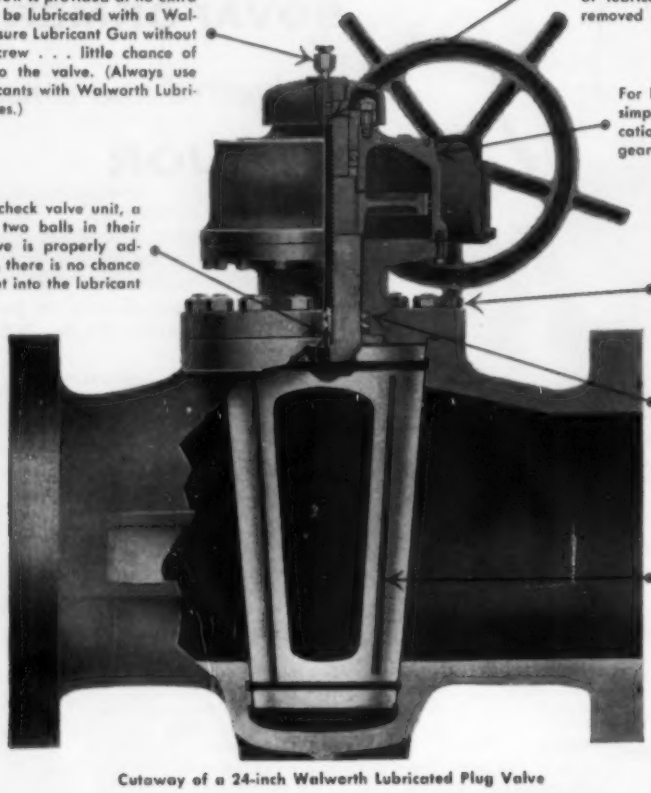
Combination button-head lubricant fitting and lubricant screw is provided at no extra cost. Valves can be lubricated with a Walworth High Pressure Lubricant Gun without removing the screw . . . little chance of grit getting into the valve. (Always use Walworth Lubricants with Walworth Lubricated Plug Valves.)

An added safety feature in the form of a groove cut part way up side of the lubricant-fitting screw allows the operator to observe any tendency of lubricant to blow out *before* the screw is removed entirely.

For buried pipelines — yoke design permits simple attachment of handwheel and lubrication extensions without modifying the gearcase.

In the stainless steel check valve unit, a transverse pin holds two balls in their seats. When the valve is properly adjusted and lubricated, there is no chance for line pressure to get into the lubricant system.

Standard bolt threads, rather than fine threads, mean easy replacement of nuts and bolts from local stocks.



Two overlapping Teflon packing rings form an effective seal against possible leakage without "grabbing" the plug shank. Low breakout torque . . . plug turns easier. Packing serves only as a seal and is not used to hold the plug in its seat.

Lubricant grooves completely frame the port openings and encircle the plug at the top and bottom assuring a tight seal against leaks. Bottom circumferential groove is separate from, but connected with, the lubricant well.

Other Walworth Lubricated Plug Valves include Single Gland and Regular Gland types. Sizes to 30 inches. Pressures to 5000 psi. and for vacuum service.

Cutaway of a 24-inch Walworth Lubricated Plug Valve

Without exception, a Walworth Ball Bearing Lubricated Plug Valve is easier to operate and maintain than any other type of rotary-action, sealed valve available today for pipeline service. Design features pointed out here show just a few advantages of Walworth Ball Bearing Lubricated Plug Valves.

Many pipeline companies throughout the world use Walworth valves for handling gas, crude, and finished products. Investigate the line of Walworth valves for your own needs. See your Walworth Distributor, or write for literature: Walworth Company, General Offices, 60 East 42nd Street, New York 17, N. Y.

Use pigs or scrapers?

Walworth Type 49 Cast Steel Gate Valves are designed on the throughport principle to permit passage of pigs and scrapers — may be installed without regard to flow direction. Sizes 2 to 30 inches inclusive. Ask for literature.

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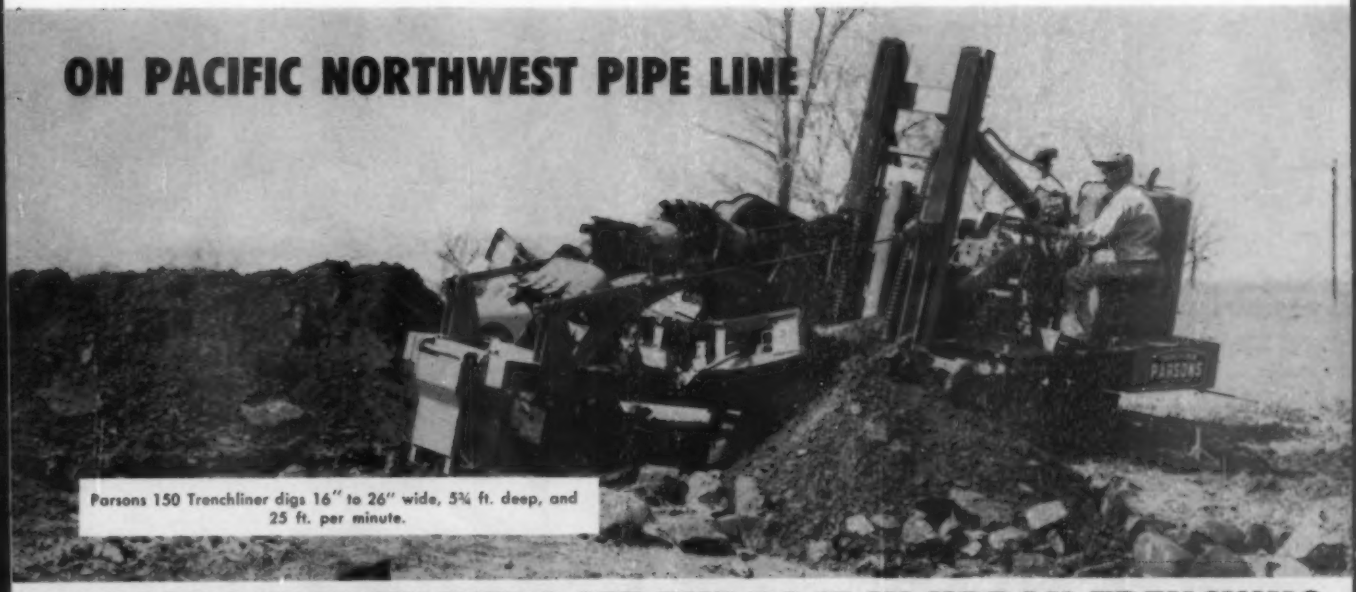

Parsons 150 Trenchliner digs 16" to 26" wide, 5¾ ft. deep, and 25 ft. per minute.

PARSONS TRENCHLINERS SET THE PACE IN URBAN TRENCHING

Your best bet for distribution system ditching . . . Parsons Trenchliners. These sturdy trenchers are right at home on Pacific Northwest Pipe Line Corporation's new gas line, helping to meet completion schedules.

Job-tested trenchers are available to pipeliners along with the Koehring line of excavators through Crutcher-Rolfs-Cummings, Inc.

Parsons 88 Trenchmobile digs 8" to 16" wide, 5 ft. deep, and 14½ ft. per minute.

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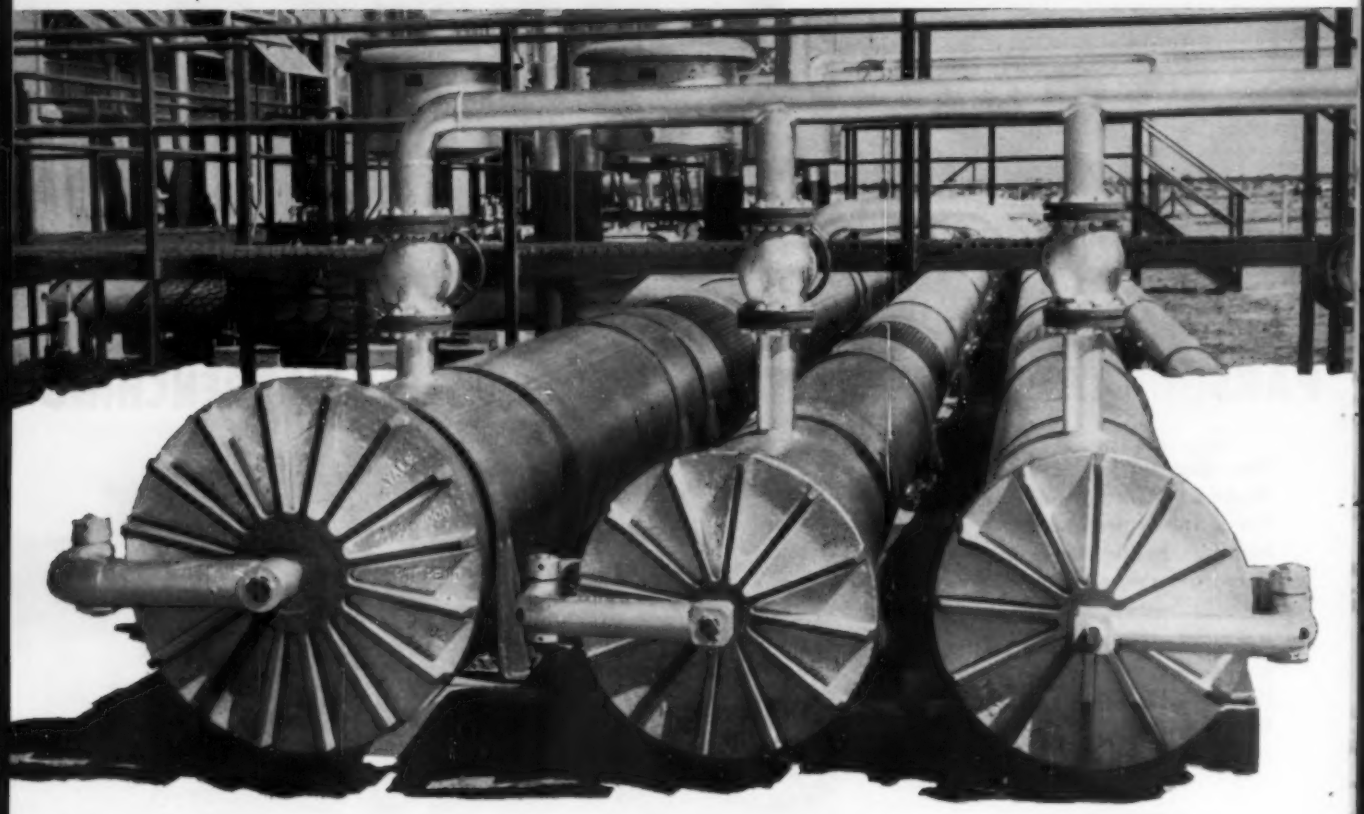

BIG HEADLINES AREN'T NEEDED to tell the story of 2-Piece Blank Caps. Their story is told over and over again, day after day, at stations the world over . . . told by their proved economy of lower first cost and practically maintenance-free operation; told by the ease, speed and safety with which they are opened and closed; **told by their unfailing dependability in effecting bubble-tight closure against gas or liquids!**

The use of 2-Piece Blank Caps on headers, traps, scrapers and blowdowns will effect great savings in **your** systems. They are furnished in every size from 2" through 38", ASA Series 400, 600 and 900. Easy-swinging hinges are available for all sizes, for horizontal or vertical installation. For complete information, write for Catalog No. 56.

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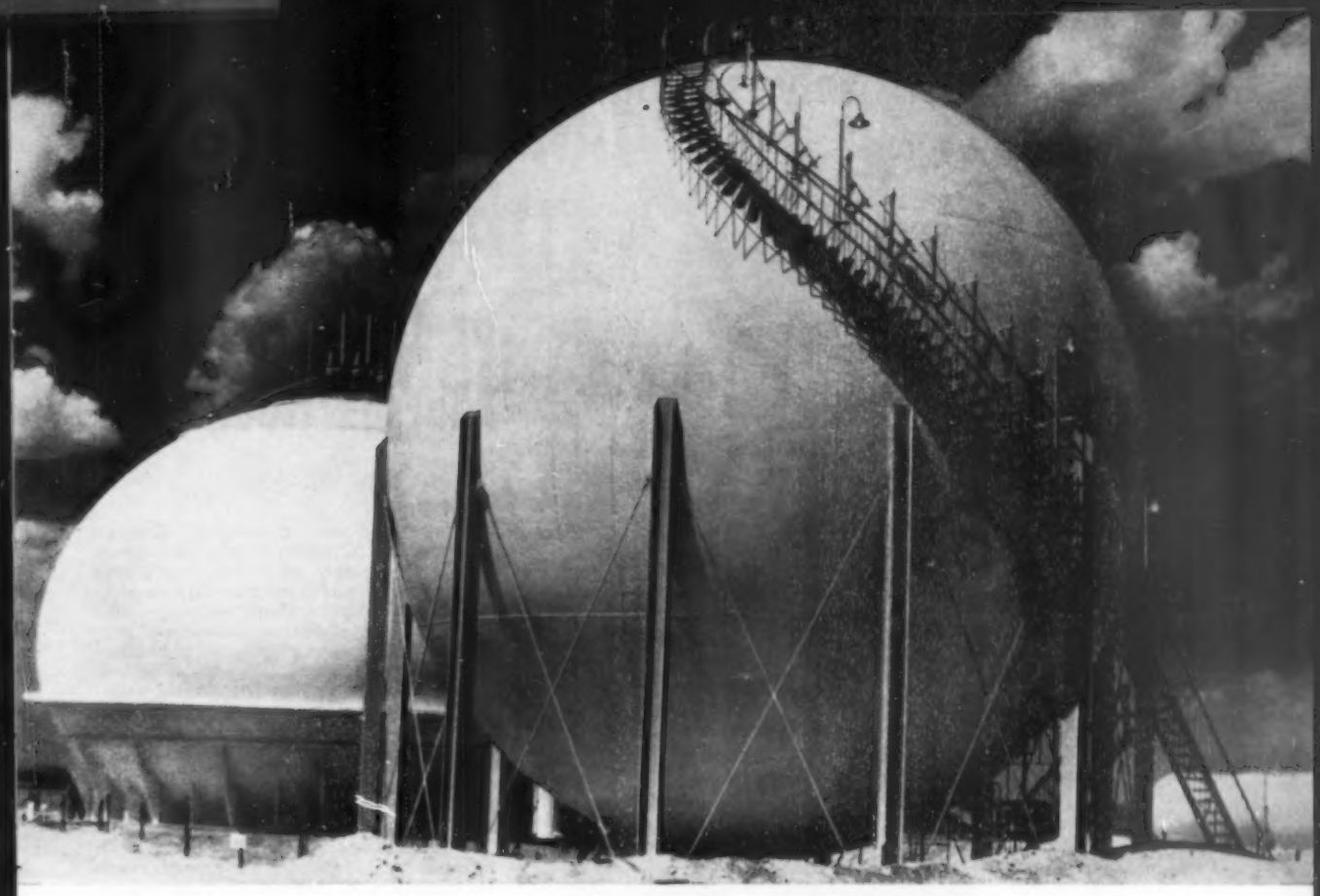

Cut evaporation losses with DULUX® Tank White Enamel

Today, major oil companies have found a way to give their huge oil-storage investments top protection against evaporation—at top economy—by painting tanks with DULUX Tank White Enamel.

REFLECTS THE SUN'S HEAT. Petroleum experts agree that painting a tank white results in heat reflectance that sharply reduces costly evaporation losses. Many users report evaporation cut close to 85% on tanks painted with DULUX Tank White. Titanium dioxide, the whitest pigment ever employed in paint, is used for maximum reflectance. And the controlled chalking of the DULUX finish prolongs this exceptional brightness. Tanks actually clean themselves.

APPLICATION SAVINGS. You save the time and expense of a two-scaffold setup when you paint with DULUX Tank White. The second coat of paint can be sprayed on immediately at right angles to the first—a single operation. DULUX applies fast, dries fast.

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Learn how you can cut evaporation losses and save on maintenance and application—write today for your free "Beat the Heat" booklet.

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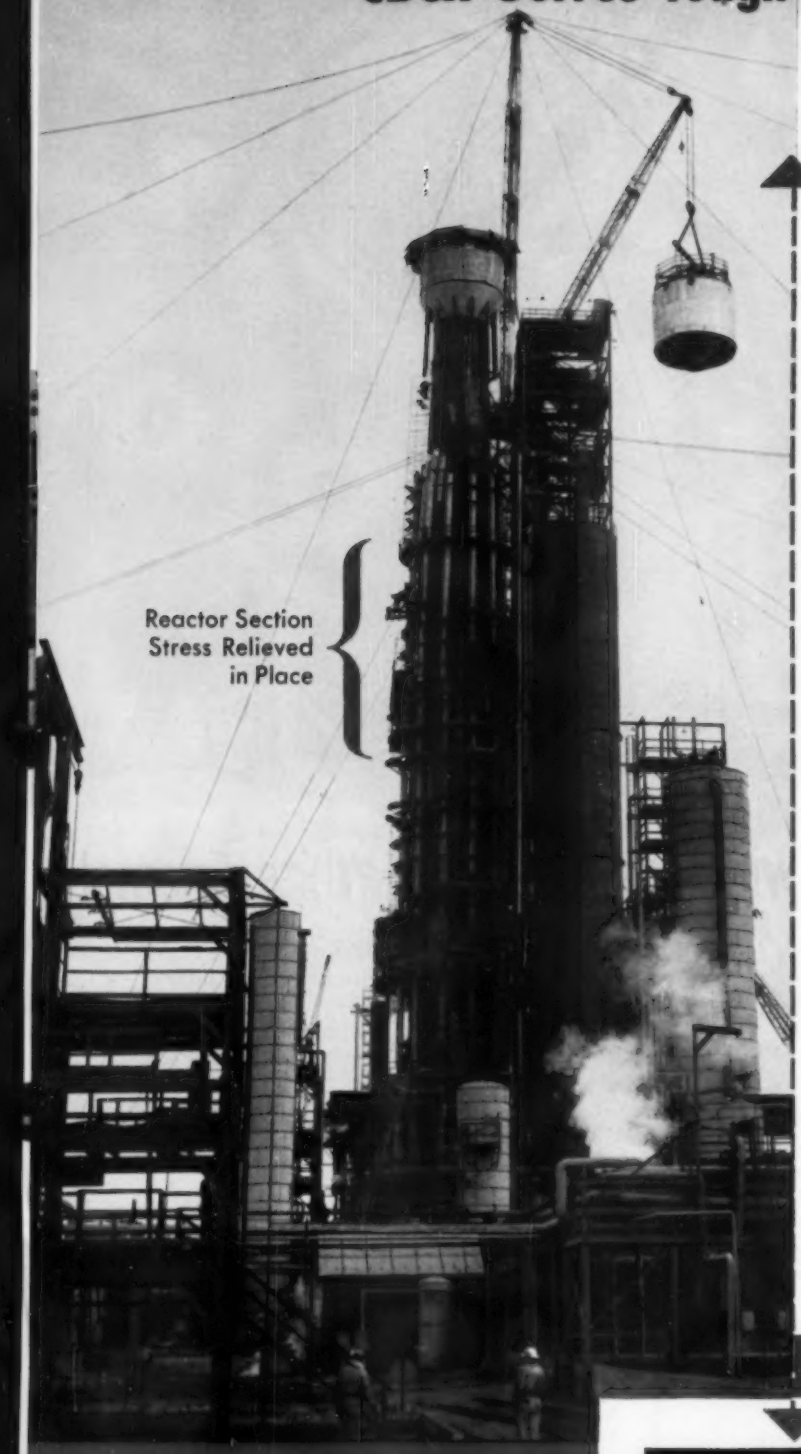
CB&I Solves tough erection problems on 360 ft. high Houdriflow Units at Toledo and Marcus Hook



360-ft. high Houdriflow unit at Marcus Hook during erection. It is one of two Houdriflow units fabricated at our Greenville and Birmingham plants through the Catalytic Construction Company for Sun Oil Company's Marcus Hook and Toledo Refineries.

Many problems confronted Chicago Bridge & Iron Company during the erection of two Houdriflow units that they fabricated and erected for the Sun Oil Company Toledo and Marcus Hook refineries. One was the lifting of 94-ton cooling coil sections 300 feet in the air. This was handled by derricks mounted on top of 283-ft. towers designed and built by CB&I especially for these jobs.

FIELD STRESS RELIEVING

Field stress relieving was an important problem that was successfully solved. Furnaces were built at Marcus Hook and Toledo to stress relieve 13 sections with internal and external heads, for each Houdriflow unit. The 70-ft. long reactor sections were stress relieved *in place* with 20-ton hot air furnaces mounted on the stair towers . . . *approximately 160-ft. in the air.*

FIELD X-RAYING

All the main seams in the reactor and regenerator, some of which were 2⅜-in. thick, were 100 per cent X-rayed in the field.

When planning steel plate structures let CB&I experience and craftsmanship work for you. Write our nearest office for additional information.

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How Many Movies Have YOU Produced?

Did you say none? Well, the truth is you have helped make *nine* movies! In fact, you—the men and women of the oil industry—are also the stars of all of them!

Each year your Oil Industry Information Committee produces a new film that tells the story of oil—*your* story. This year's film—"Destination Earth"—is a Technicolor cartoon. It shows why Americans are served far better by our free competitive oil industry than they would be by a government-controlled oil industry.

How can you make your movies pay off for you? *You* can be the person who makes these nine films available to your social or church groups as well as local theaters and schools. For more information about how to obtain these films write to your OIIC district office—or to the address below.

The Film Program is only one of the many ways the OIIC helps win friends for the oil industry and build better public relations for you. By putting OIIC materials to work in your community you'll not only help your industry but you'll experience a great feeling of personal satisfaction as well.

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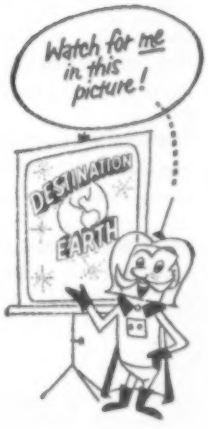


PROCESS CONTROL THROUGH REFRACTIVE-INDEX MEASUREMENT

Refractive index is directly related to the composition of a liquid mixture. The Consolidated-Phillips 38-201 Process Refractometer puts this basic principle to work . . . accurately and automatically indicates changes in composition by *continuously* measuring the refractive index of a flowing liquid sample and comparing it to a liquid standard. (Even complex streams can be monitored when all but one or two key components remain reasonably constant, and a binary mixture is thereby approximated.)

Samples may be obtained directly from the process stream to be controlled. Comparison signals from the instrument's optical-servo system are then used as part of a control loop to maintain optimum throughput and product quality and to keep processing costs at a minimum. For the complete story of the 38-201 Refractometer, send today for Bulletin CEC 1839-X26.

Send us your stream-analysis problems...

The Process Refractometer has been used successfully in the automatic control of many processes, e.g., fractionation and blending in the petroleum refining industry. Consolidated's Application Engineering Section will be glad to study your own stream-analysis problems and submit a complete report on the 38-201's applicability to your work. Just send us a description of your process . . . there's no obligation.

OPERATIONAL FEATURES

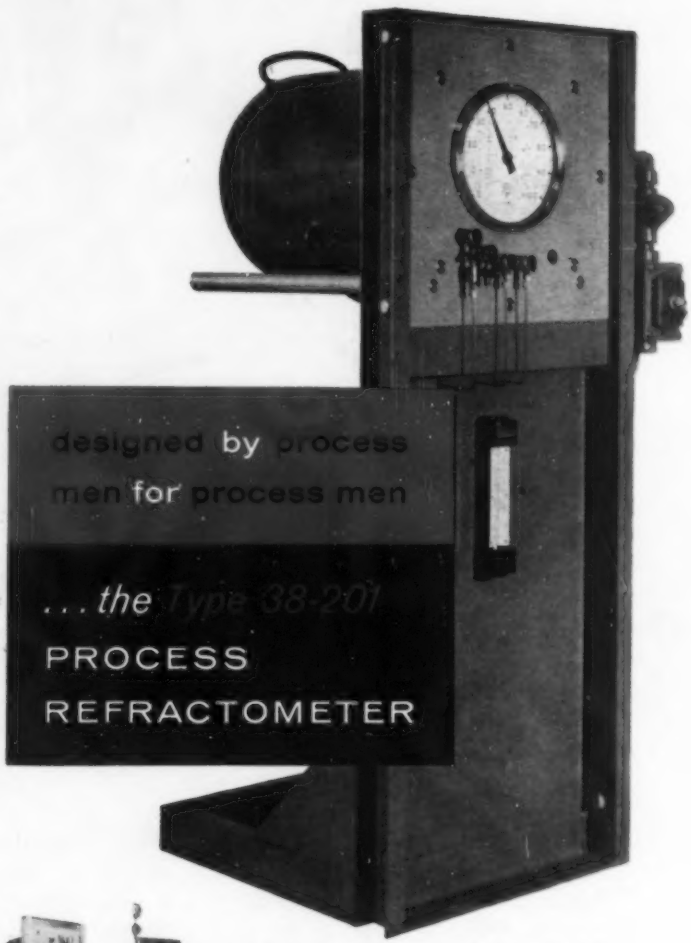
RUGGED CONSTRUCTION—explosion-proof design permits use anywhere, even out-of-doors.

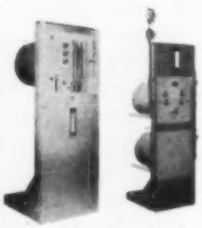
STABLE, DRIFT-FREE OPERATION—the differential-principle design provides freedom from ambient temperature changes. Sample temperature, pressure and flow are closely controlled and stabilized.

HIGH SENSITIVITY—a difference of 0.000012 refractive-index units can readily be detected. Unit observes both plus and minus deviations of the flowing sample being monitored.

SIMPLICITY—contains no controls requiring routine adjustment; once unit has been placed in operation, the operator makes only an occasional inspection.

FREEDOM FROM MAINTENANCE—basic design simplicity keeps unit operating without attention for long periods.





OTHER CONSOLIDATED-PHILLIPS PROCESS-CONTROLLERS . . .

In addition to the Process Refractometer, CEC offers the 38-301 Oxygen Analyzer for monitoring and controlling oxygen content in gaseous streams and the 38-401 Ultraviolet Analyzer for checking purity and recovery of aromatic and diolefin streams.

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The place of the engineer and scientist in modern management is examined here by a research specialist . . . First he takes a look at the technical man, then studies management's functions before showing how the specialist can be fitted into management

Is Management for the Specialist?

Gilbert C. Jacobus

The atom and the sun may in distant time become prime energy sources for both industry and home; but, for the foreseeable future, petroleum will continue to be the major energy-producing industry.

Today, most of the oil and natural gas produced in the United States is used chiefly for lubricants or fuel. A portion, however, is consumed by a multi-billion dollar chemical industry producing organic chemicals.

This tremendous industry is in short supply of scientists and engineers. Almost as scarce is good management material. Now the question arises — Can specialists be developed into management? Should they be?

Technical Specialists Get Management Responsibilities

In the technological side of such an industry, the engineer and scientist are at home for here they deal with the physical world on which their education and early experience have concentrated. But the magnitude and complexity of the industry force the engineer and scientist into another world, too, the world of organized group effort.

Without realizing what takes place, many technically trained people find more and more that time and effort must be diverted to other than technical activity. Such things, as planning ahead for others, coordinating activities of others, evaluating performance, dealing with conflicts of various types, and otherwise getting work done through others, take precedence over strictly technical or engineering work. For many years now the drift from purely technical to general management posts among the half-million engineers in industry and government in the United States has been continuous. This is well illustrated by a study conducted in the Department of the Navy in 1953.

"The same trend is found among the 51,000 engineers employed by the Federal Government, the largest professional occupational group on the public payroll, with the exception of government administrative staffs. A survey of the management aspects of 1350 senior engineers' jobs in the Navy Department in July, 1953, showed that 60 to 80 per cent of the senior engineers' time is spent on management duties rather than on straight technical work. Often their shift to these responsibilities seems to have occurred as a result of the inherent nature of their jobs rather than agency planning or individual initiative."[1]

Characteristics of the Technical Specialist

By and large, the scientist or engineer finds difficulty in realizing that people are creatures of emotion to a far greater extent than of logic. Engineers, for example, have been found to lack empathy and real interest in people. Definite trends which characterize the main body of mechanical engineers have been stated by one research team to be:[2]

1. "Mechanical engineers are emotionally stable.

2. "Interpersonal relations are harmonious but casual. Impersonality is one of their more common traits.

3. "An analytical interest in people is rare.

4. "They avoid introspection and self-examination. Insight is often shallow. This lack of understanding makes them less perceptive of social nuances and relatively insensitive to the less obvious needs of others.

5. "They are straightforward, direct, and self-sufficient.

6. "They are inclined to be matter-of-fact and, outside their own field, are often unimaginative.

7. "Their attitudes are realistic, though their brand of realism deals more with surfaces than with depths.

8. "They are energetic; — when faced with problems, they are advocates of the direct action approach. Polite diplomacy and oblique conciliatory tactics are foreign to their nature.

9. "Most are goal-oriented, serious-minded, and conscientious.

10. "They like phenomena to be definitely structured; there is a fundamental aversion to ambiguity. This fondness for structure and order may underlie their essentially authoritarian approach.

11. "Social participation is normal in amount, more as a matter of conventionality and social conformity than because of a profound interest in people. It is not true that engineers are usually introverts. What sometimes makes them appear so is their characteristic impersonality."

[1] "The Engineer Manager: Training the Technician for Executive Responsibility," J. C. Stephens and G. C. Jacobus, American Management Association's *Personnel*, March, 1954.
[2] "Profile of the Mechanical Engineer," R. Harrison, D. T. Tomblen and T. A. Jackson, *Personnel Psychology*, Vol. 8, No. 4, p. 469.

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He has received the Legion of Merit, the Order of the British Empire, and many other awards for his work with U. S. forces.

Management Development in an Engineering Organization

The foregoing list of traits highlights some of the major problem areas with which we must deal in introducing and conducting management development in an engineering organization. To corporations, both large and small, in the petroleum industry, problems of the management development of scientific and engineering personnel are highly important because of the large number of such people employed. Organizational effort, based upon a sound underlying philosophy, is required to meet this need.

For example one man states:

". . . within many corporations you will discover a constant effort to encourage and develop the individual within the framework of group action.

"In the Jersey Company, for example, we have long recognized, as a matter of practical efficiency, how deadening the effects of too much centralization can be. Some degree of conformity, uniform policy, and uniform procedure is necessary for any organization. But to the fullest extent possible, we decentralize our operations and delegate authority so the individual will have room to develop and express his abilities. We haven't found all the answers, but we do feel that we are on the right track as long as we continue to strive toward that goal."[3]

Development Objectives

What should be the goals of management development? Generally, we find these expressed in terms of:

(1) Enabling an individual to do better on his present job.

(2) Helping an individual to increase his potential to advance to higher responsibilities.

Various programs state their purpose in slightly different ways. For example:

Detroit Edison says their purpose is: "(a) To help supervisors do a better job in their present position. (b) To help supervisors develop their full potential. (c) To have qualified people ready to step into vacancies as they occur."

Westinghouse Electric states their purpose is: "(a) To help management personnel become more effective in their present assignments. (b) To insure an adequate supply of management reserves at all levels."

Esso Standard Oil says: "(a) To build a reserve of qualified people as replacements for key management positions. (b) To assist management people to function more effectively in their present jobs."

Gulf Oil Marketing Division says: "To insure an adequate reserve of personnel thoroughly qualified to assume management duties of responsibility at all levels."

McKesson and Robbins says: "(a) To make our **first team of management men stronger**, to make it function more smoothly, and to make it more effective. (b) To develop adequate reserves."

Johnson and Johnson, Inc., Manufacturing Division says: "(a) To provide development activities that will help management personnel to meet the growing challenge of their jobs and to progress within the Manufacturing Division in accordance with the policy of promotion from within. (b) To develop the abilities of each executive to handle higher-level responsibilities. (c) To develop greater breadth and flexibility in management personnel."

In relation to these statements, we should note particularly two things. First, there is great similarity in content. Second, there's an obvious indication that a management development program can be conducted in an entire company or in one division of an organization. This is important to an organization that wants to think in terms of setting up a "pilot" operation before committing itself company wide.

Management Functions Found at All Levels

In dealing with problems of management development, we need to define for ourselves what we include in management. In all organizations there are certain functions performed by management people regardless of the level to which they are assigned. Examples of this are:

1. **Providing leadership:** Application of that human factor which impels people in an organization to move willingly and cooperatively toward the accomplishment of definite business objectives.

2. **Communicating and its very close associate, motivating:** The manner of passing information and understanding to others, coupled with the will to do, which, added to the skill for accomplishing a job, produces the best work.

3. **Maintaining good human relations:** Managing persons as well as things; giving proper weight to social and psychological wants in addition to the economic wants of members of the work-group.

4. **Planning:** Seeking out facts, understanding them and establishing interrelationships in advance of doing.

5. **Organizing:** Setting basic objectives and, in conformance with plans, creating an organizational structure that facilitates the accomplishment of tasks.

6. **Controlling:** Assuring performance in accordance with plans through the setting of standards of performance, appraising accomplishments in terms of standards set, coordin-

[3] "The Individual in a Group Society," Commencement Address Before the Graduating Class of Lehigh University, June 16, 1952, by Frank W. Abrams, Chairman of the Board of Directors of Standard Oil Company (New Jersey), published in THE LAMP, June 1952.

ating efforts of the group or groups, gaining acceptance of any necessary changes, removing interferences or delays to carrying out the plans.

7. Training: Getting oneself and other management people to recognize and react properly to a variety of circumstances, to capitalize on strengths and to overcome weaknesses.

Variances in Management Functions at Different Levels

Another factor affecting management development is the difference in management functions found at the first-line supervisor level, middle management and top management.

In the case of a first-line supervisor, there are three elements of major difference: (1) his almost constant association with employees at the production-work level; (2) the immediate responsibility for production always imposed upon the first-line supervisor; and (3) the fact that he is the one who must transmit management directives to people not part of management.

In middle management, there is somewhat a broader scope of activity, usually without getting into company-wide policy formulation. Association with employees at the production level is reduced, most contact being through the first-line supervisor. Analysis of organizational problems frequently looms large.

Top management finds itself almost wholly divorced from contact with employees at the working level. Here a major responsibility is application of the company-wide view, broad policy formulation that preserves balance among organizational and individual interrelationships.

Points Basic to Management Development

In planning a program for an individual, it's important to make provision for adequate development, but to avoid over-development.

What are the kinds of work the management man is called upon to perform at the level where he is working? What kinds of techniques are best for the job he has to do? What's the individual's potential for growth in relation to management? How rapidly can this particular individual progress in his development as manager?

Plans should take organizational needs into account, developing several men for each key executive position, at the same time making it possible for individuals to be candidates for any one of several executive positions.

This creates organizational flexibility that otherwise seldom is present. It has appeal also from the standpoint of ready availability of cadres for expansion which may unexpectedly loom on the business horizon.

Concepts basic to management development are opposed to a high degree of specialization.

Engineers and scientists tend to become experts in a limited field of application. Management development seeks to broaden a man's knowledge, views and capabilities to the end that he may coordinate a variety of skills and activities.

The environment in which management development is undertaken must motivate and foster self-development.

Everyone on the management team, who is filling his job adequately, is continuously engaged in three activities simultaneously. First, he is doing the job currently assigned. Second, he is learning the next higher job. Third, he is training his subordinate. Each of these involves phases of the man's own growth, but top management primarily is the echelon that sets and molds the pattern creating the climate of an organization, whether stimulating or restrictive.

The success of management development in any organization will be in direct ratio to the extent to which the program is geared to the needs of participating individuals.

Gaps in knowledge of management techniques must be filled. Job rotation, if employed, should start with individuals at lower levels of an organization. Rotation between staff and line is sometimes difficult to accomplish in the case of engineers or scientists, but usually can be done on at least a temporary basis.

When this is done, however, it's important for the individual concerned to understand how it fits the pattern for his future. In some instances, gaps in knowledge can be filled best through additional academic training. Universities everywhere will be found ready and willing to meet such needs.

Do's and Dont's of Managment Development

1. **DO** set up a sound management appraisal sytem.

This means a system that is consistent in relation to the measurements achieved; one that is not too abstract; one that is acceptable to those using it and to those affected by it; one that provides reasonably accurate (not necessarily perfect) results.

2. **DON'T** fail to have a post-appraisal conference between supervisor and subordinate, building a warm, sincere, permissive relationship between the two.

3. **DO** place responsibility for an individual's development in the joint care of the subordinate and the supervisor.

4. **DON'T** fail, in running a management development program, to build very carefully and to maintain staff-line management relationships that emphasize the key role of line supervisors; work with the problems and needs of the line management man.

5. **DO** recognize and be willing to accept the existence of natural resistances to training; be alert to all possible ways to minimize such resistances.

6. **DON'T** fail to maximize participation on the part of all affected by the program.

7. **DO** be willing to intermix levels and groups for broad training on company problems.

8. **DON'T** hesitate to use pilot groups to bring to light needs of individuals and organizational units; to try out new training ideas; to test training opportunities.

Elements of the Case Method Conference

One of the oldest, most widely used of group training techniques is the case method conference. It's one of the most effective, if used properly.

This type of conference fosters teamwork; creates understanding.

This give-tand-take at the conference table develops morale.

It establishes more effective channels of communication.

It appeals to practical-minded people.

There are some shortcomings, however. The possibility of one or two persons dominating the conference must be watched. Second, if conferees are neither experienced nor informed in the area of discussion, the result is a pooling of ignorance and prejudice, rather than knowledge and logic. Third, lack of a skilled discussion leader reduces markedly the extent to which group thinking and learning are achieved.

The major steps such a conference involves are:

1. Gaining knowledge of the situation to be discussed

(usually through reading a case presentation, although the so-called "incident process" technique may be employed as a variant).

The discussion leader has to see that the group understands the subject matter and the purpose of the conference. He should indicate areas to explore in most cases. He should arouse a sense of dissatisfaction with the situation as it is to foster the effort to think.

2. Determining primary and subsidiary issues involved in the case.

The group must define specifically the problem or problems to be solved. Usually, concentration on one problem becomes difficult because a number of problems exist. The discussion leader should focus effort on achieving a decision as to what must be solved to eliminate any unsatisfactory situation. After identifying problems, the group must decide on an order of priority for discussion.

3. Analysing the facts available and determining what's missing.

Isolation of fact from hearsay or opinion is important. Identification of missing elements, a condition prevalent in actual situations, is also important. Related to this is recognition and weighing of intangible factors.

4. Discerning possible solutions.

This forces group thinking. Usually, it's helpful to list all, or at least, several solutions before attempting to evaluate any one of them. When a group immediately proceeds to examine the merits of the first solution offered, there's a strong tendency to center attention on that to the exclusion of possible alternatives.

5. Deciding upon the best solution.

This, of course, involves weighing the benefits and detriments of the various solutions offered.

6. Indicating what action should be taken to meet the needs of the case.

Too often, when a group decides upon a "best" soiution, the participants feel so good about it they fail to go on to decide how the solution will be carried out and by whom.

Management Development in the Petroleum Industry

In common with other industries, corporate management in the petroleum industry has to be vitally concerned with increasing the number of competent management people as well as perpetuating leadership for the enterprise. In search for managerial talent, inevitably scientific and engineering personnel will be scrutinized for candidates.

Advancement to a position of management responsibility really means a change of occupation for a scientist or engineer.

He immediately assumes the responsibility of directing the activities of others. From that point on, his personal progress depends upon more than just proficiency in his technical specialty. Especially if placed in charge of a major organizational element, such as a district, a division or a plant, the technically trained specialist finds the importance of his technical competency dwindling. The emphasis on human capabilities — getting work done through others — and conceptual capabilities, dealing with broader administrative problems, becomes greater.

The president of E. I. Du Pont de Nemours and Company, trained as a chemical engineer, has pointed out that:

"Today specific skill in any given field becomes less and less important as the executive advances through successive levels of responsibility. Today, for example, there are thousands of people in the Du Pont Company whose expertness in their special field I can only regard with awe and admiration. And to make the sad cycle complete, I have been out of touch with by own field of chemical engineering for so long that I cannot even talk on equal terms with the young men of that profession who are joining the ranks of the Du Pont Company today."[4]

The petroleum industry is large, varied and complex. A multitude of talents is employed to perform its functions. Undoubtedly personal advancement will always be possible in specialized fields. But there is a duty to face up to the needs of the organization; in a larger sense to responsibilities to the nation. Esso Standard Oil Company has pointed out:

"In a large organization, steps must be taken to spot promising executives and accelerate their development so that they are ready for top positions at an age when they can contribute maximum service. This requirement is so urgent that it cannot be left to chance."[5]

The Technical Specialist

The answer to the question, "Is management development for the technical specialist?", must be in the affirmative as soon as such a person becomes more than an individual worker. When that happens, the man concerned must broaden his horizons to become something more than a technician, however competent he may be in his specialty.

Management development for the technical specialist needs to be on a planned, programmed basis, with primary impetus originating from within the organization concerned. There must be recognition that management development essentially means self-development. Management development requires learning situations in which an individual gains understanding and acceptance of his own needs.

Management development derives from experiences that are meaningful to the individual by starting where he is in understanding and behavior, and leading him into new associations in thinking and acting. The individual must be given information and contacts in such a way that he can have objective awareness of his own behavior, new insights into the functions of management, and greater sensitivity for the attitudes and feelings that exist in his relationships with others.

Management development requires learning situations that incorporate in the individual's experiences guidance and support by his superiors. It requires systematic follow-up to give the individual concerned knowledge of the results of his learning as measured by his superiors, and incentives to motivate him to higher level accomplishment.

Management development is primarily a matter of forming right attitudes, gaining knowledge of techniques and achieving skill in application to the end that the individual may become an effective leader of organized group effort.

[4]"The Management Profession," Crawford H. Greenewalt, *Advanced Management*, December, 1955, p. 6.
[5]Building Leadership for Today and Tomorrow, Management Development in Esso Standard Oil Company, 1953, p. 3.

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Ninth of a series

Communication:

Ten Aids to Logical Thinking

Dennis Murphy

DO you ever feel jostled this way and that by so many different communications that you scarcely know what to believe? Because we live in a world-wide welter of conflicting opinions, we're a natural target for political speeches, editorials, radio and TV talks, advertisements, sermons, and reports. Consciously or unconsciously, the thinking in them is often dishonest, illogical, or faulty.

Exactly What *Can* We Believe?

Our government — city, county, state, and federal — can almost be called government by public discussion. In fact, we believe in (1) rule by majority vote and (2) free and honest discussion. Let's focus on that word *honest*.

Our ability to convince others is important, but our capacity to be convinced is equally important if we're to function intelligently as free citizens. And isn't that one of our first duties? Nobody wants to be told he doesn't think straight, yet most of us wish we could think straighter.

This article tries to expose some fallacies in thinking that we meet with every day. Maybe you're already aware of them, but a quick review might help us detect them in others and avoid them in ourselves.

1. Distinguish Fact from Opinion

A *fact* is something that has been proved and can be proved again. It has actuality and reality. We accept a fact because it is indisputable. "The temperature is now 70 deg in this room." We can read the thermometer to confirm or contradict this fact. We accept facts without any argument.

An *opinion* is a personal judgment or feeling about something. Since no two persons are exactly alike, we can't expect them to judge or feel quite alike on anything. Their opinions are bound to differ. "It's too warm in this room!" and "It's too cool in this room!" are the honest opinions of two persons in it. You may believe either one. Or neither of them — if, *in your opinion*, the temperature is just right. So, we can respect other people's opinions without either accepting or rejecting them, or we can argue all over the lot about opinions without getting anywhere!

Franklin, a true doubter who liked to argue in his youth, tells in his *Autobiography* how he learned to advance his opinions without antagonizing others. He says he cultivated the habit of using modest terms,

> *". . . never using, when I advanced anything that may possibly be disputed, the words certainly, undoubtedly, or any others that give the air of positiveness to an opinion, but rather say, I conceive or apprehend a thing to be so and so; it appears to be, or* **I should think it so and so,** *for such and such reasons; or* **I imagine it to be so;** *or* **is it so, if I am not mistaken.** *This habit, I believe, has been of great advantage to me when I have had occasion to inculcate my opinions, and persuade men into measures that I have been from time to time engaged in promoting; and, as the chief ends of conversation are to* **inform** *or to be* **informed,** *to* **please** *or* **persuade,** *I wish well-meaning, sensible men would lessen their power of doing good by a positive, assuming manner, that seldom fails to disgust, tends to create opposition, and to defeat every one of those purposes for which speech was given to us — to wit, giving or receiving information or pleasure."*

Opinion is not what is or was; it's what we believe or suppose. It may be right or wrong — the result of bias, prejudice, misinformation, or wishful thinking. Trouble comes when someone tries to make us accept his opinions for the facts — because *he* doesn't know the difference. Greater trouble arises when we accept opinions for facts — because *we* don't know the difference!

Another thing: opinion and fact are interwoven and fired at us so fast we don't have time to ferret out the fiction from the truth. So we have to accept everything or nothing. Suppose someone says, "John D. Rockefeller, who lived from 1839 to 1937, exemplifies a true Christian in business because, after dissolution of the Standard Oil Trust in 1892, he became America's foremost philanthropist." Fact, opinion, fact, opinion. As receivers of information, we are duty-bound to let

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honest doubt suspend our judgment until we can find more facts, more evidence.

2. Gather Sufficient and Reliable Evidence

Evidence is those facts that constitute proof. Evidence is both testimonial and circumstantial. The first is direct; the second, indirect. Human testimony — whether we get it in a book, talk, report, editorial, or court trial — is only as reliable as the intelligence and integrity of the person who communicates it. Yet some people are lulled into accepting almost anything because of the dignity of print, the reputation of a person, or the prestige of an organization back of the community.

In our conscious search for truth, we should get into the habit of testing and weighing the evidence that supports ideas, feeling, and oral or written statements. And while we test others, we should test ourselves just as rigidly. Are we trying to be fair? Do we recognize two or more sides to an issue? Can we realize that it's seldom all-black or all-white, but contains many gradations of gray? Or do we feel biased or prejudiced in favor of one side rather than another?

Do we possess enough facts to be well-informed on the matter? Is our knowledge up-to-date or outmoded? These are questions we have to keep asking ourselves to avoid roadblocks to straight thinking and just decisions.

3. Avoid Hasty Generalizations

Don't jump to conclusions! If we could see the humor in this, we'd agree with the French critic who said, "All generalizations are lies, including this one!" Greek, Roman, and medieval scholars used causal reasoning by deducing that whatever is true of a whole category will be true of one of its parts.

They based their *deductive reasoning* upon the well-known syllogism with its major premise, minor premise, and conclusion.

Deductive method (Latin *de* plus *duco,* meaning "to lead from")

All engineers are mathematicians. (major premise — general)
Don Klop is an engineer. (minor premise — specific)
Therefore, Don Klop is a mathematician. (conclusion)

The trouble with this method is getting a valid major premise, which may need some qualification with a "nearly," "generally," or "almost."

Roger Bacon (1214-1294), often called the founder of modern science, argued for observation rather than arm-chair theory. He adopted the lens for use in the microscope and predicted the airplane, steamship, automobile, and suspension bridge. For all his study, he was charged with black magic and imprisoned for 10 years. But his namesake, Francis Bacon (1561-1626) dropped the much-abused syllogism and established the experimental method of *inductive reasoning.* Trying to get valid major premises, he found this method as reliable as the multiplication tables.

Inductive method (Latin *in* plus *duco,* meaning "to lead into")

Don Klop is an engineer and a mathematician. (proved by tests)
Sam Blow is an engineer and a mathematician. (proved by tests)
Joe Doak is an engineer and a mathematician. (and so on through many cases)
Therefore, all engineers are mathematicians. (conclusion)

Careful induction, the method of modern science, doesn't jump rapidly from a few isolated and uncertain cases to its general axiom. Instead, it patiently studies the facts to find a common denominator and arrives at its conclusion safely and surely. It accurately uses facts, evidence, statistics, graphs, observation, experimentation — every legitimate means of arriving at truth.

The inductive method makes a wide enough sampling to be sound, and it takes note of those exceptions that "prove" (that is, "test") the rule. In the same manner, objective researchers and report writers note exceptions that may or may not affect their conclusions. In spite of our painstaking care, we're probably aware of many untrue generalizations we've had to refute because of exceptions: *all* athletes are stupid, beautiful girls are dumb, businessmen are dishonest, Negroes are lazy, professors are pedantic, and Irishmen are hotheaded. Hasty generalizations.

What we need to remember is this: no two people are exactly alike. John$_1$ is not like John$_2$. John$_1$ today is different from John$_1$ tomorrow, and John$_1$ in one environment is different from John$_1$ in another environment. Time, place, and personality are only a few of the conditioning factors that cause something to appear right — to me now, up to a point, as far as I know!

Samuel Butler, the author of *Erewhon,* once noted: "Life is the art of drawing sufficient conclusions from insufficient premises." That's enough to wrap up this section on hasty generalizations.

4. Be Wary of Firsts, Universal Superlatives, and Statistics

We can prove that Washington was our first president, but we can't prove that the Wright brothers were the first to fly an airplane or that Samuel Van Syckle was the first to lay a crude-oil pipe line. They weren't. Many a *first* that goes unchallenged can be disproved by careful research. So we're more accurate when we say "one of the first" or "among the first."

Americans (*all* of us, I suppose!) are often accused of an overfondness for superlatives, especially of size. Biggest salary, tallest building, largest stadium, biggest corporation, fastest car, best movie of the year, prettiest girl in America each year, and so on. Bigness in itself is neither a fault nor a

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The Meaning

virtue. A tiny etching may be well-nigh perfect; an immense mural, woefully imperfect.

Logical thinking makes us avoid statements like "We have the *finest* educational system in the world" or "William Faulkner is our *greatest* novelist. Finest, *with reference to what?* Specify. Amount of money spent on it? Number of students attending? By what standards do we compare? Have we examined other systems? Greatest novelist, *with reference to what?* Specify. Even if we had read all other American novelists, we would still be voicing an opinion.

Just as we need to check and double-check firsts and superlatives, so should we examine statistics carefully. As Alfred North Whitehead in *The Aims of Education* wrote: "To talk sense is to talk in quantities. It is no use saying the nation is large — How large? It is no use saying that radium is scarce — How scarce? You cannot evade quantity." True, but for comparisons we need an accurate reference, a constant basis for just comparison.

When presented honestly, statistical evidence is persuasive proof. But unfortunately, statistics is one of the most misused forms of support. Statistics can be accurate, oversimple, elliptical, misleading, or downright dishonest. Figures are cited in an annual report to show a company has made its greatest gains in 1955. Gains in what? Over what? With reference to what? Compared with what? And often 14,000 apples are added to 17,000 peaches to give 31,000 pears!

Read Darrell Huff's excellent little book, *How to Lie With Statistics;* and remember Disraeli's three kinds of lies: plain lies, damn lies, and statistics.

5. Don't Misuse Analogy

Analogy, or comparison, points out resemblances between two objects, ideas, institutions, or the like — literally or figuratively. The basis of analogical reasoning is: if two things possess similar characteristics, a proposition that is true of one may be true of the other. For example, if a certain tax or law has succeeded in Iowa, it is sound to assume that it will succeed in Kansas. But this is still an assumption, not a proof.

If the comparison is one we've overlooked and is accurate in fundamental aspects, we find the revelation almost as enlightening as more solid proof. But if the resemblances are few, doubtful, and far-fetched, we simply don't accept them. At best, analogy illustrates rather than proves.

6. Don't Evade or Beg the Issue

Evading the issue, or ignoring the question, is illogical and reveals a mind unable or unwilling to grapple with the problem at hand. Little Mary says to her brother, "Your hair's all messed up. Go comb it!" Johnny, noticing jelly on her cheek, retorts, "Your face is dirty. Go wash it!" And away he struts, elated with having won the argument.

Childish as this may seem, many an argument in business is won without any more logical support. It sometimes seems, in fact, that the chap with a quick come-back or ready answer is the one who advances.

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The Purpose

In my own family of 10 rambunctious children, I was the ninth son. Our indoor sport was arguing, often on then- risqué subjects we hoped might shock our Victorian mother a little. Once after I had debated eloquently for birth control, Mother said quietly but crisply, "Well, if *I* had believed in birth control, where would *you* be?" That shut me up in a hurry.

Evading the issue, wittily entertaining as it may be, offers no logical proof in support of a question. Instead, it diverts attention, closes the question momentarily, and puts us right back where we started.

Begging the issue is assuming the truth of something not yet proved. "You ask me if I have stopped lying yet. I'll answer when you tell me this: Have you stopped beating your wife yet?" A favorite strategy of one type of lawyer is to load his question by begging the issue, thereby trapping an unsuspecting witness in the cross-examination, no matter how he answers.

"The only way to eliminate the dangers of drunkenness on commercial airlines now serving hard liquor is the passage of Bill 19, which will be supported by all right-minded congressmen." This kind of cocksure statement, offering assumptions as proved facts, shuts out logical questions: How many airlines serve liquor and what is their report? Why is Bill 19 called the "only way"? Can't the airline companies control this danger where it exists? What proof is offered that congressmen will support this bill? And how is a right-minded congressman determined?

7. Guard Against "Non Sequiturs"

Non sequitur is Latin for "it does not follow." The term is used in logic to label an inference that's not supported by its premises. Don't let this fancy term mystify you, even if you never studied Latin, for you probably know this fallacy without knowing its technical name.

Let's look at this example from a newspaper before election day: "Joe Blow is a veteran of World War II, the father of five children, an active church member, and should therefore be re-elected to this office." And here's an example from a letter of recommendation: "I have known Miss Mary Graham for 12 years and am sure she will prove an excellent secretary in your company."

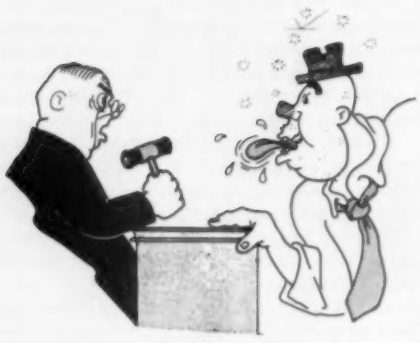
Aside from the emotional appeal, the premises can often be proved; it's the conclusion of the *non sequitur* that hiccups. It simply doesn't follow! Something is illogical about the order of the cause-effect concepts because the conclusion exceeds the sum of the facts. Consecutiveness, a basic principle of straight thinking, is violated.

The study of logic and mathematics is an excellent way to learn consecutiveness. Sequence is implicit in numbers. A *non sequitur* is like 1-2-3-0-5 instead of the orderly 1-2-3-4-5 series; we have to go back and get the 4 in place before we can proceed to 5. Or 6 x 6 has real meaning *before* 36; after "36 equals" we might have 18 x 2, 12 x 3, 9 x 4.

8. Avoid the "Post Hoc Ergo Propter Hoc" Fallacy

Post hoc ergo propter hoc is simple Latin for "after this, therefore because of this." Here, time-space concepts get all mixed up with cause-effect concepts. Erroneously we reason that because B happens after A, B happens on account of A. B is therefore caused by A or is the result of A.

Here's an example: "Nation-wide suffrage of our women bore fruit when they voted for liquor prohibition, which lasted for nearly 14 years." Now this sounds Jim-dandy and plausible enough. But the prohibition (18th) amendment went into effect January 16, 1920; the woman suffrage (19th) amendment went into effect August 26, 1920. Through *post hoc ergo propter hoc* reasoning, we can attribute speak-easies of the 20's to woman suffrage, the depression of the 30's to prohibition, and World War II of the 40's to the depression! And so on.



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The Evidence

9. Don't Argue Beside the Point

Medieval books on logic listed a lot of ways to argue beside the point when the point itself could not be defended or assailed. Some of these were appeals to fear or a threat, to material interests, to people's ignorance, and to pity or related emotions. Three common forms are these:

Argumentum ad hominem (personal) diverts attention from the facts to the personality of the opponent. If your case falls apart, the strategy is to **get personal!** It's as if you said: "Your case and arguments are too sound for me; so I'll attack and belittle your reputation, work, and habits. If I can deflate **you,** maybe your arguments won't carry any weight!" Political campaigns are often full of personal abuse that is wholly beside the point.

Argumentum ad populum (popular) attempts to sway popular feeling and support for or against an issue. "The American way of life," "our democratic process," "every honest taxpayer knows," and "the cure of Big Business" are stock-phrases slanted for a stock-response.

Argumentum ad verecundiam (traditional) works for acceptance by using venerable authority, great men, ancient customs, and thought-blocking sacred cows to produce the illusion of proof. "Our Founding Fathers who fought and died for our priceless heritage," "Washington's admonition to avoid all entangling alliances," and "science has proved" are examples.

10. Recognize Propaganda

Almost everything we read, see, and hear carries an element of *propaganda* to influence our thoughts, feelings, and actions. Webster defines it as "any organized or concerted group, effort, or movement to spread particular doctrines, information, etc." The Bible is great propaganda for living. And this article itself is propaganda slanted toward a purpose.

There are two extremes in propaganda: (1) the honest promotion of honest purposes, however mistaken they may seem to us; and (2) the deceitful promotion of selfish or criminal ends. Between these extremes lie all kinds and gradations of propaganda. If we *look for the bias* in everything that's communicated to us, we can unmask a lot of objectionable propaganda and be less gullible to error.

Some propagandists are as tricky as Cesare Borgia, who advised his guest: "If you had lunch with Charles of France this noon, you were poisoned! Here, let me get you an antidote!" And then *Borgia* gave him the poison.

Nobody can escape propaganda in today's world of newspapers, radio, movies, and television — the Big Four in communication — with their competition and commercial advertising. The Institute for Propaganda Analysis has exposed seven devices: name calling, glittering generality, transfer, testimonial, plain-folks appeal, card stacking, and band-wagon hot air. But these don't cover half the devices of dishonest "selling." Crooked thinkers know all these devices; honest men have to learn them for self-defense.

You'll catch propaganda even in jokes. Note this one: a Russian school teacher asked a pupil, "Who were the first human beings?"

"Adam and Eve," the kid replied.

"And what nationality were they?"

"Russian, of course."

"Fine, fine," the teacher commented. "And how do you know they were Russian?"

"Easy," said the kid. "They had no roof over their heads, no clothes to wear, and only one apple for the two of them — and they called it Paradise!"

So What?

Since we can never *avoid* or escape propaganda, we can at least be on our guard and *recognize* the bias, the fallacies, and the Big Lies. In this way we can make deductions, allowances,

Question
Your Decision

or total discounts in communications. This goes for all 10 forms of fuzzy thinking just discussed.

We'll all be safer and straighter in our thought processes if each one asks questions like these:

(1) Who's communicating? Can I trust this authority? Why should I believe him when I can think for myself? **Question the authority.**

(2) Specify what you mean? Do I understand exactly what you mean? Are we using common terms of reference? **Question the meaning.**

(3) Where's your evidence, support, or proof? Do you have enough? Are there other ways of looking at this issue? **Question the evidence.**

(4) Why are you interested in communicating this to me? Why do you care what I think, feel, or do about the matter? **Question the purpose.**

(5) How *am* I going to react to this issue? **Question your decision.**

Then, if we really want to help others think straight, we can do it best by thinking straight while we communicate with them. If we are humble and patient, we can often help them get back on the subject.

Finally, we can all remember these principles:

(1) *Consecutive thinking* achieves order, harmony, and balance.

(2) *Selective thinking* sifts the significant from the insignificant.

(3) *Sound thinking* insures the logical rightness of the whole and its parts.

(4) *Stick-to-it thinking* adheres strictly to the subject.

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P. E. Staff Group takes to the Field

On workover job, for Gulf Oil Corporation in the Pierce Junction field, group poses for photo. Left to right, front row: Charlie Walker, Gulf Oil; Chuck McKean, Dallas; Bill Faville, Pittsburgh, John McDonald, Dallas, Jess Adkins, Dallas, Ed Sealey, Dallas; back row, left to right: Roger Motheral, Houston; Dick McKey; Pasadena, Calif.; Joe Russell, Jr., Gulf Oil; Abbott Sparks, Dallas; John Wallace, New York; and Cy Perkins, Chicago.

EARLY in August, management of The Petroleum Engineer called into Dallas district advertising managers from the West Coast, New York, Chicago, Pittsburgh, and Houston. They joined forces with Dallas department heads including circulation, sales promotion, market research and advertiser services, for an extensive market research and sales conference.

After a few days at the conference table, the entire group was flown to the Gulf Coast area for an inspection tour of plant and field operations of specific types. Editors acting as hosts, organized and led the 14-man tour through a concentrated and thorough schedule. Working from sun-up 'til sun-down each day, the group visited drilling rigs, a workover rig, flowing and pumping wells, tank batteries, a modern gasoline plant, a newly-completed crude oil pump station, a large refinery, a gas compressor station of the future, and administrative headquarters of a large natural gas transmission corporation. The photo story that follows touches some of the highlights of their close look at equipment applications, and operations pertinent to those divisions of the industry in which PE specializes; namely drilling and producing, pipelining, refining and natural gasoline.

Details on tank battery manifold in Pierce Junction field are explained by Gulf engineer, Joe Russell, Jr., left to right are: John McDonald, Cy Perkins, Dick McKey and Chuck McKean.

Plant engineer, Jack Chancellor, center, takes last PE group through Hastings gasoline plant. Left to right are: John McDonald, Jess Adkins, Chancellor, Ed Sealey and Jim LeVelle, Engineering Editor.

The old and the new in crude oil pump stations are seen side-by-side at Humble Pipe Line Company's Webster Pump Station near Galveston, Texas. The old station, seen at right, has been moth-balled for emergency operations, while modern electric centrifugal pump station (not shown) takes over. In foreground is part of a mammoth manifolding system for controlling flow of crude from a number of Gulf Coast fields.

Rig floor inspection of tongs, rotary and drawworks includes, left to right, John Wallace, N. Y.; Roger Motheral, Houston; Dick McKey, Pasadena; Abbott Sparks, Dallas; Cy Perkins, Chicago; and John McDonald, Dallas.

A newly-completed dual producer for Gulf Oil in Pierce Junction field, PE group gets first hand story from Joe Russell, Jr., far right, explaining flow from casing annulus and tubing flow line.

At Stanolind's Hastings Gasoline Plant, John Thomas, plant superintendent, second from left, takes one PE group on tour through absorber section. Left to right are: Dick McKey, Thomas, Don Taylor, Gulf Coast Editor, Abbott Sparks, and Roger Motheral.

Plant foreman Charles Edwards, second from left, provides operating information on Hastings gasoline plant to Bill Faville, left, John Wallace, Cy Perkins and Chuck McKean.

At Transco headquarters in Houston, dispatcher explains complete gas pipe line system to, left, John Wallace, Abbott Sparks, Chuck McKean, Bill Faville, Jess Adkins and Ed Sealey.

Compressor station of the future, Transco's Station 23, is described to PE group by station superintendent M. E. Dougall, at left in shorts. Bending an ear are: Hank Kastrop, Don Taylor, Jess Adkins, Ed Sealey and Roger Motheral.

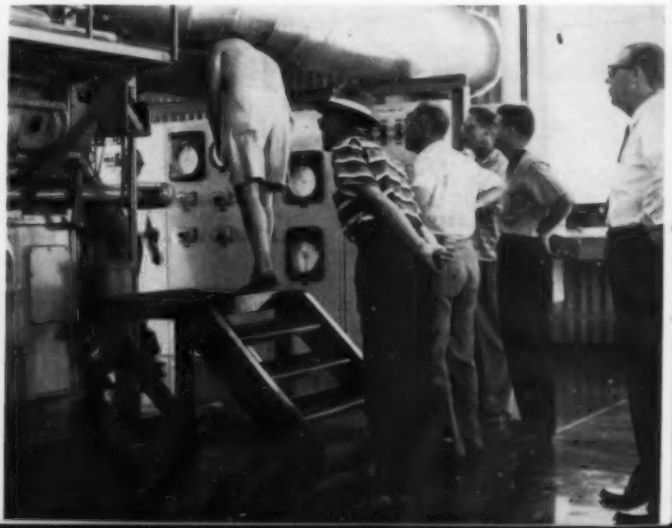

FIG. 1. The huge Kama Sea, formed by damming the upper reaches of the Kama River in Molotov Province by hydroelectric project, has flooded the area of the once-dry Polazninsk oil fields. In this northern section of the "Second Baku" region, oil is now extracted from beneath the reservoir, the derricks standing on man-made islands.

P 131.

Russia Makes Slow Progress In 'Second Baku'

Labor and hold-up of supplies cut average drilling to 1755 ft per rig per month . . . Most of 9000-mile pipe line construction scheduled in Sixth Five-Year Plan is for this region . . . Refineries to be constructed will use crudes from Bashkiria and Tataria Republics

Charles L. Adams

TWO neighboring Soviet autonomous republics — Bashkiria and Tataria — hold the key to the success of Russia's ambitious oil production program under the Sixth Five-Year Plan (1956-1960).

If Bashkir and Tatar output comes up to the glowing potential described by Soviet geologists and government officials, the USSR's production goal of 135,000,000 metric tons[1] annually by the end of 1960 seems assured. As the Russians see it, only the lack of basic construction — housing, roads and utilities — and persistent inefficiency and waste mar the petroleum industry's rosy outlook in this region.

Center of the so-called "Second Baku" area between the Volga River and the Ural Mountains, Bashkiria and Tataria have figured prominently in Russia's petroleum picture only since the end of World War II. Previously their output was far overshadowed by Azerbaijan's Baku fields on the Caspian Sea.

Both autonomous republics have now surpassed Baku's production, and the margin is steadily widening. Almost all of the tremendous increase in the USSR's postwar petroleum output, which jumped from 38,000,000 metric tons in 1950 to 71,000,000 metric tons in 1955, has come from Bashkiria and Tataria plus the provinces of Kuibyshev, Saratov and Stalingrad to the southwest and Molotov to the north. By 1960, about 75 per cent of Russia's oil is to be taken from this area.

Meanwhile Baku's wells, which have produced over 700,000,000 metric tons of oil since the first Apsheron Peninsula deposits were tapped in 1871, have been yielding less than before World War II. Developments in the USSR's other far-flung oil regions from the Ukraine to Sakhalin have not been spectacular.

During the Fifth Five-Year Plan (1951-1955), Bashkiria increased its oil output by 170 per cent, almost quadrupled its refining capacity, and became the Soviet's top petroleum-producing region. Bashkir oil ouput is slated to leap another 120 per cent during the Sixth Five-Year Plan, and Kremlin directives call for "at least doubling" of proved reserves in the same period.

By the end of 1960 Tataria expects to be supplying the USSR with almost three times as much oil as Baku produces at the present time. Over five billion rubles were invested in Tatar petroleum development during the past

[1] A metric ton is equivalent to 7.266 bbl (avg.).

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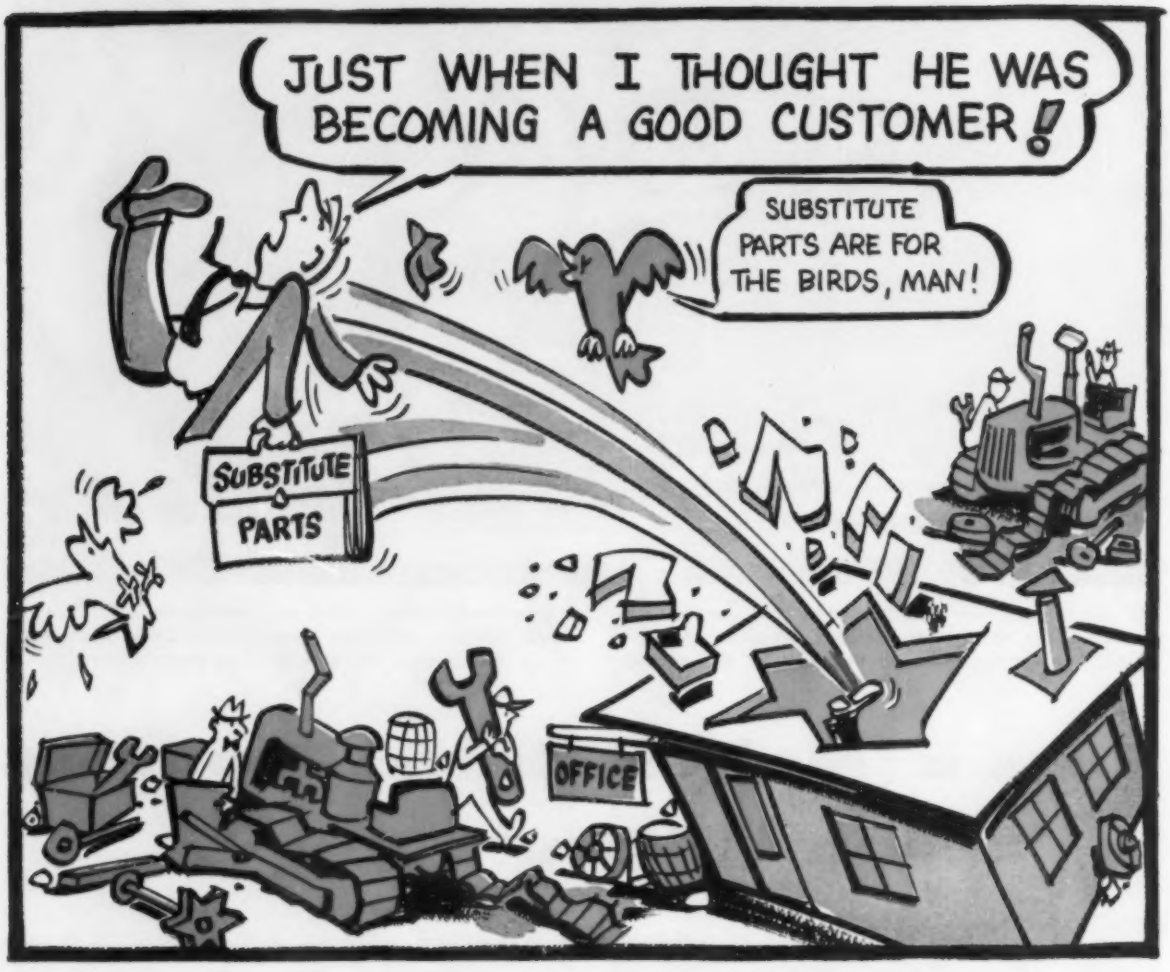

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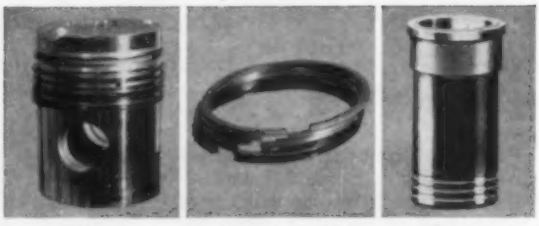

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FIG. 2. Comparatively new field in Kuibyshev Province's Zhiguli Hills near Volga River.

five years, and output has increased 15-fold.

Between 1951 and 1955, a total of 1,800,000 meters[2] of hole were drilled in Tataria. The goal for the 1956-1960 period is 5,400,000 meters.

Importance of the Bashkir and Tatar Autonomous Republics to overall Russian petroleum needs is emphasized by the fact that most of the new 9000-mile pipe line network for crude and refined products proposed under the Sixth Five-year Plan will originate in this area. By the end of 1960, pipe lines are to carry Bashkir oil 2300 miles eastward through Siberia to Irkutsk, northward to Molotov, and westward to the large industrial centers of Gorky, Yaroslavl, Ryazan and Moscow.

One of Russia's major objectives during the next 10 years is forced-draft industrialization of Siberia. "Second Baku" oil will play a major role in developing this vast area between the Ural Mountains and the Pacific Ocean.

The Russians frankly admit that oil discoveries in Siberia have been very disappointing during the postwar period, although a vigorous search continues. Sakhalin's wells fall far short of being able to supply the petroleum requirements of the USSR's Far Eastern provinces.

As a result, the trans-Siberian railroad has become a heavily overburdened petroleum carrier.

The new Russian blueprint calls for completion of additional pipe lines from the Tuimaza field and Ufa to Omsk in western Siberia, making a total of four nearly-parallel links between the two points. Thus all of the crude required for the new Omsk refinery, now in partial operation, will come from the "Second Baku."

A new refinery in the Krasnoyarsk area of central Siberia — to be started before 1960 — will be fed "Second Baku" crude as the Omsk pipe line is pushed eastward to Irkutsk.

Construction of another refinery in the upper Amur River valley in eastern Siberia will also get under way within the next few years and will be completed before 1965. By that time it, too, will be receiving "Second Baku" crude from a further extension of the Omsk-Krasnoyarsk-Irkutsk line.

Ultimately, a 4000-mile trans-Siberia pipe line will carry "Second Baku" oil to the Far Eastern industrial center of Khabarovsk, north of Vladivostok. Meanwhile, oil refining capacity in the "Second Baku" area itself is being steadily increased.

The Novo-Ufa refinery at Ufa, which was placed in operation in 1951, has been steadily expanded during recent years and is now one of the largest in the Soviet. It is supplied by pipe line from the Tuimaza and Bavlinsk fields. The Novo-Ishimbai refinery, which gets its crude from fields south of Ufa, is being placed in operation by stages.

Refineries at Kuibyshev, conveniently situated on the Volga River, are assuming increased importance. Oil production in Kuibyshev province, south of Tataria, is soaring spectacularly. By the end of 1957, Kuibyshev hopes to become the third region to surpass the original Baku's current daily petroleum production.

Important "multi-million ton" discoveries and exceptionally thick producing horizons have been reported in Kuibyshev's Kinel-Cherkassky area. Late last year a good oiler was completed in the Krasnoyarsk area (not to be confused with the Siberian center only 28 miles from the city of Kuibyshev).

Bashkiria and Tataria already are able to produce oil cheaper than any other area of the USSR. The government newspaper Izvestia figures the unit cost is about a third as much as for the higher-quality oil obtained from Baku and Grozny. Despite such statistics, Russia admits that conditions throughout the "Second Baku" are "far from satisfactory." It has called for "resolute action" to cope with a long list of deficiencies.

Lack of pipe lines is one of the most pressing problems. M. A. Yevseyenko, minister of the petroleum industry, disclosed that oil and oil products shipments in the first two months of 1956 were over a million tons behind schedule.

With transport facilities clogged, oil production had to be cut back at fields in Tataria and in Kuibyshev and Stal-

FIG. 3. Tatar oil workers examine a bit.

[2]One meter equals 3.2808 ft.

FIG. 4. Laying a section of the Omsk-Irkutsk pipe line which will carry "Second Baku" oil into central Siberia.

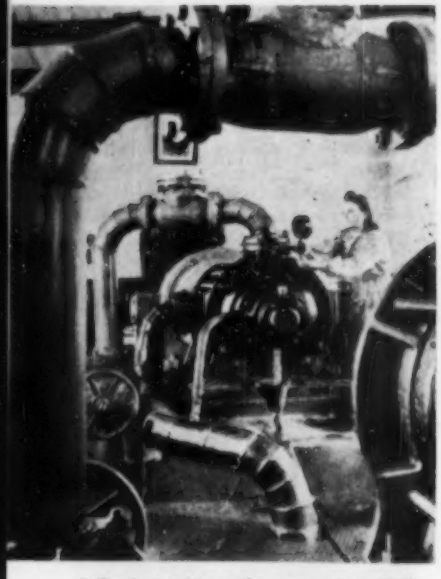


FIG. 5. Interior of a pumping station which helps maintain high pressure in oil strata of Bashkiria's Tuimaza field.

ingrad provinces. Operations at a number of refineries in the "Second Baku" region were also reduced for the same reason. The Novo-Kuibyshev refinery alone was unable to supply 67,000 metric tons of gasoline in January "due to delivery problems."

"Second Baku" crude is now delivered by pipe line to refineries at Kuibyshev, Ishimbai and Saratov as well as at Ufa and Omsk. By the end of 1960, the proposed new pipe lines are slated to carry "Second Baku" crude to refineries in Moscow, Gorky, Yaroslavl and Ryazan.

Whether these pipe line projects will be completed on time causes no little concern among "Second Baku" oil men. They note, for example, that the first Ufa-Omsk oil products line was put in operation years behind schedule and the first Tuimaza-Omsk crude pipe line went in service considerably after the first units of the Omsk refinery were completed.

Until recently the Tuimaza-Omsk line was being used at less than 50 per cent of capacity because intermediate pumping stations hadn't been finished. Meanwhile, oil boom centers have sprung up haphazardly in the "Second Baku" despite the Soviet Union's highly-touted "planned economy." Older towns such as Bugulma in Tataria have tripled in size since 1950. New cities of 10,000 to 20,000 population have risen where not even the smallest hamlet existed a few years ago.

Much of the housing in the mushrooming cities of Ishimbai, Almetyevsk, Leninogorsk, Oktyabrsky and Belebei is crude and temporary. Municipal services are few and unreliable. There is little industry other than oil. Food, consumer goods, building materials and oil field supplies have to be brought in over primitive roads.

Nevertheless, oil production continues to soar, being limited in some areas only by the lack of transportation. By 1960 the urban population of Bashkiria and Tataria is expected to double the 1955 level.

A Bashkir official, S. D. Ignatyev, described many of his republic's oil problems earlier this year in a speech before the Twentieth Communist Party Congress in Moscow. He declared:

"The oil industry is the leading branch of our republic's economy. In 1955 our oil workers fulfilled their plan by 105 per cent, and production is increasing. But along with our undeniable achievements there are still many major shortcomings that inflict severe material loss on the government.

"Sometimes mineral wealth vital to the nation is wastefully destroyed. This is especially true of oil well gas, which is still burned.

"As the workers themselves express it, our oil districts remind one of a land of fire worshippers. At Tuimaza we were unable to stop burning gas until ten years after the fields were opened. Gas is still burned at many other oil fields in the republic and even at refineries. Meanwhile, Bashkir industrial plants, as well as those of neighboring provinces in the Urals, are in great need of this valuable fuel and raw material for the chemical industry.

"A number of new and important oil deposits have been discovered recently in Bashkiria. However, the oil ministry either does not appropriate any money for their development or does not appropriate nearly enough.

"The Chekmagush and Kaltasa fields may remain unexploited in 1956 for this reason, even though ministry officials have personally inspected them and admitted they are good. The Shkapovsky field is also in bad shape, and the USSR Ministry for Construction of Oil Industry Enterprises is to blame. The Ministry is doing intolerably poor work in developing the deposit, gives little help to construction organizations in setting up production and technical facilities, and is unreliable in supplying materials and means of transportation.

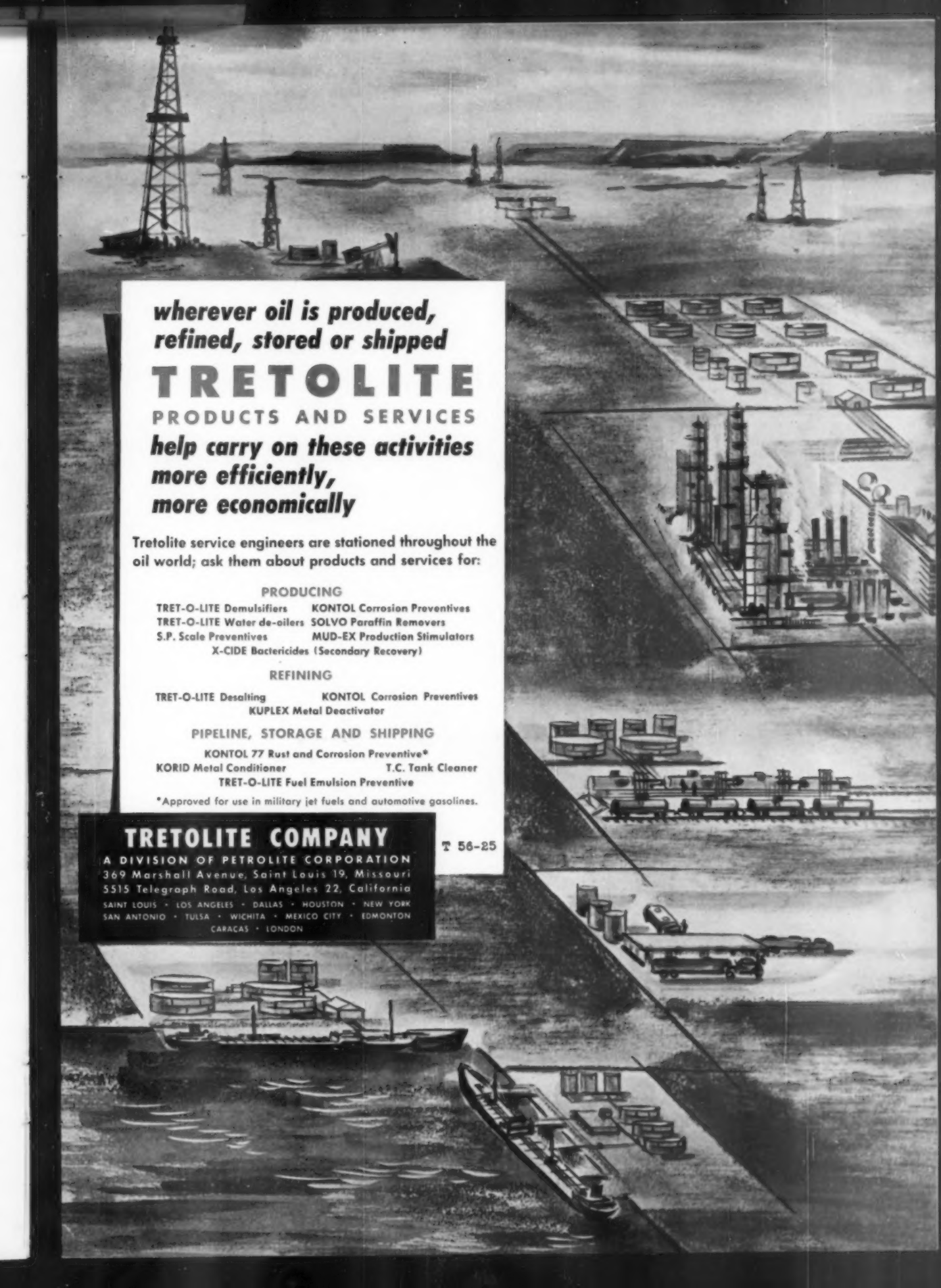
"It is possible that further delay in construction would mean that the wells will stop flowing under their own pressure. This would require a shift to pumping; the amount of oil obtained might drop; and the unit cost of oil would increase. This cannot be permitted."

Ignatyev reported that "great opportunities" exist for increasing Bashkir oil output. He announced that another discovery of Devonian oil had been made only a few days previously in the Belebei area. But, he continued, development work there is also unsatisfactory.

"It is well known that oil extraction, exploratory and operational drilling, and all other work in the industry goes on the year around. We have long winters which are usually cold and snowy. Under these conditions, good auto roads — roads that are open all the time — are of great importance.

"At one time a qualified road-building organization was set up in Bashkiria. It was able to do only a little work before it was transferred in 1953 to another part of the country. Thereafter road construction in the republic's oil regions stopped. This had an extremely harmful effect on exploitation of previously discovered deposits and on the finding of new ones.

"In 1955, the Ministry of Highway Transport and Highways formed another road-building organization; but it is still very poorly supplied with machinery. If it is not strengthened soon



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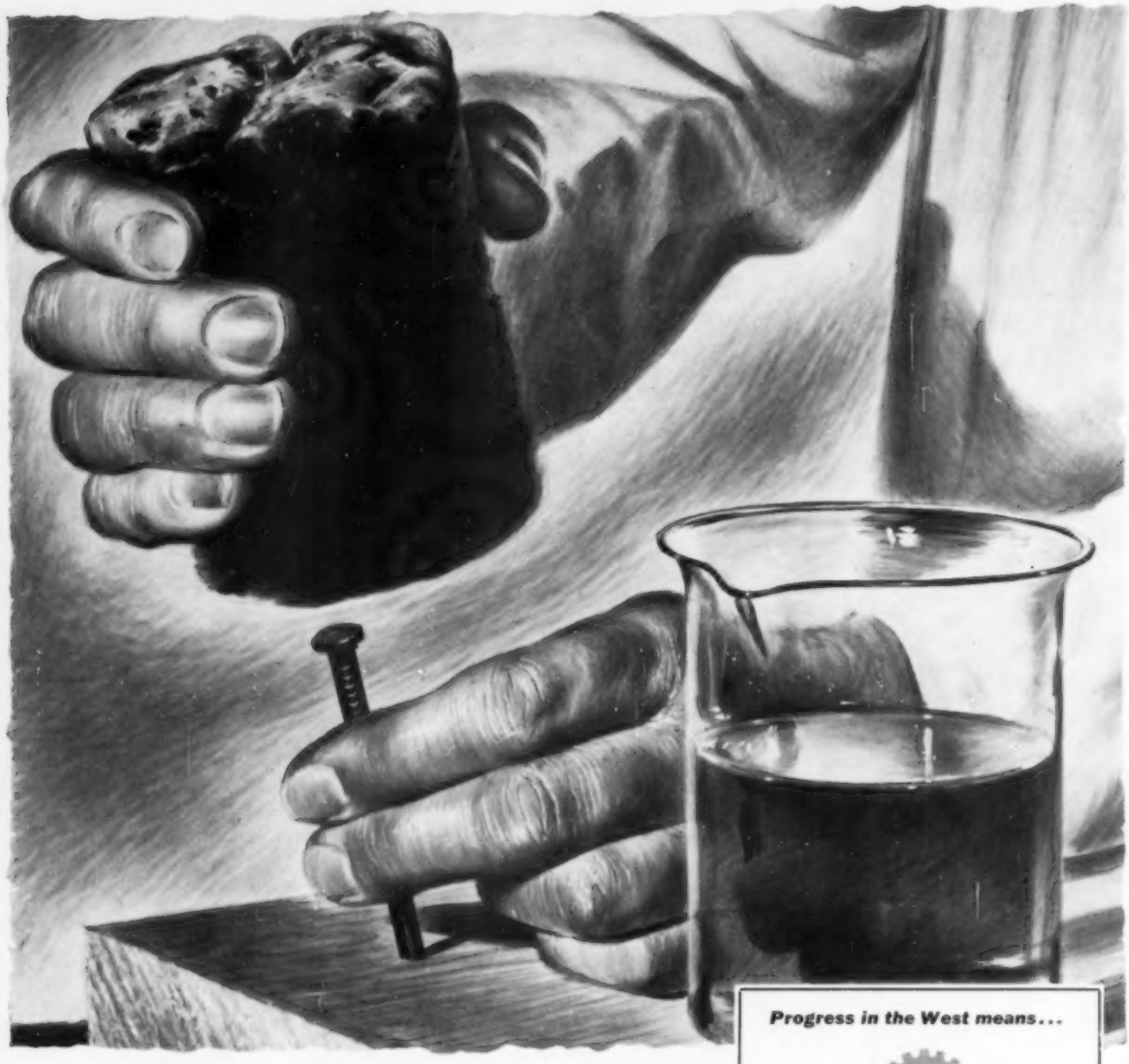
Standard's new radiation-resistant lubricants are helping put atomic power to work



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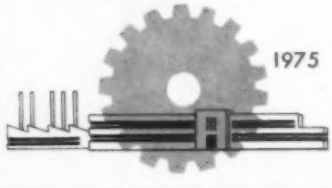

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we will not be able to handle our tasks. Lack of good roads results in mass stoppages and loss of valuable oil."

Ignatyev disclosed that a shortage of electricity is developing in the Bashkir oil regions (as it is in other parts of the "Second Baku"), resulting from insufficient power capacity and a lack of power lines. By 1957, he asserted, the shortage of electric power in the republic will have become considerably more acute.

The director of the Bashkir Oil Federation, S. Kuvykin, told of more troubles in an article in Izvestia. He said:

"Bashkir oil workers have steadily increased labor productivity and reduced the unit cost of oil through use of new and progressive technology. However, the situation is not satisfactory with regard to putting completed wells into operation.

"Intensified contour flooding is vital to forced extraction (secondary recovery). All major producing areas under the Tuimaza and Oktyabrsky Oil Field Administrations now employ contour flooding. However, water is still not being pumped continuously under the oil seams at the Tuimaza deposit. We are also pumping too little water into some of the Tuimaza seams.

"The conservation officials of the Ishimbai Oil Administration in exploiting new deposits by old methods without maintaining seam pressure is completely intolerable. This could lead to rapid depletion of the wells and to incomplete removal of the oil.

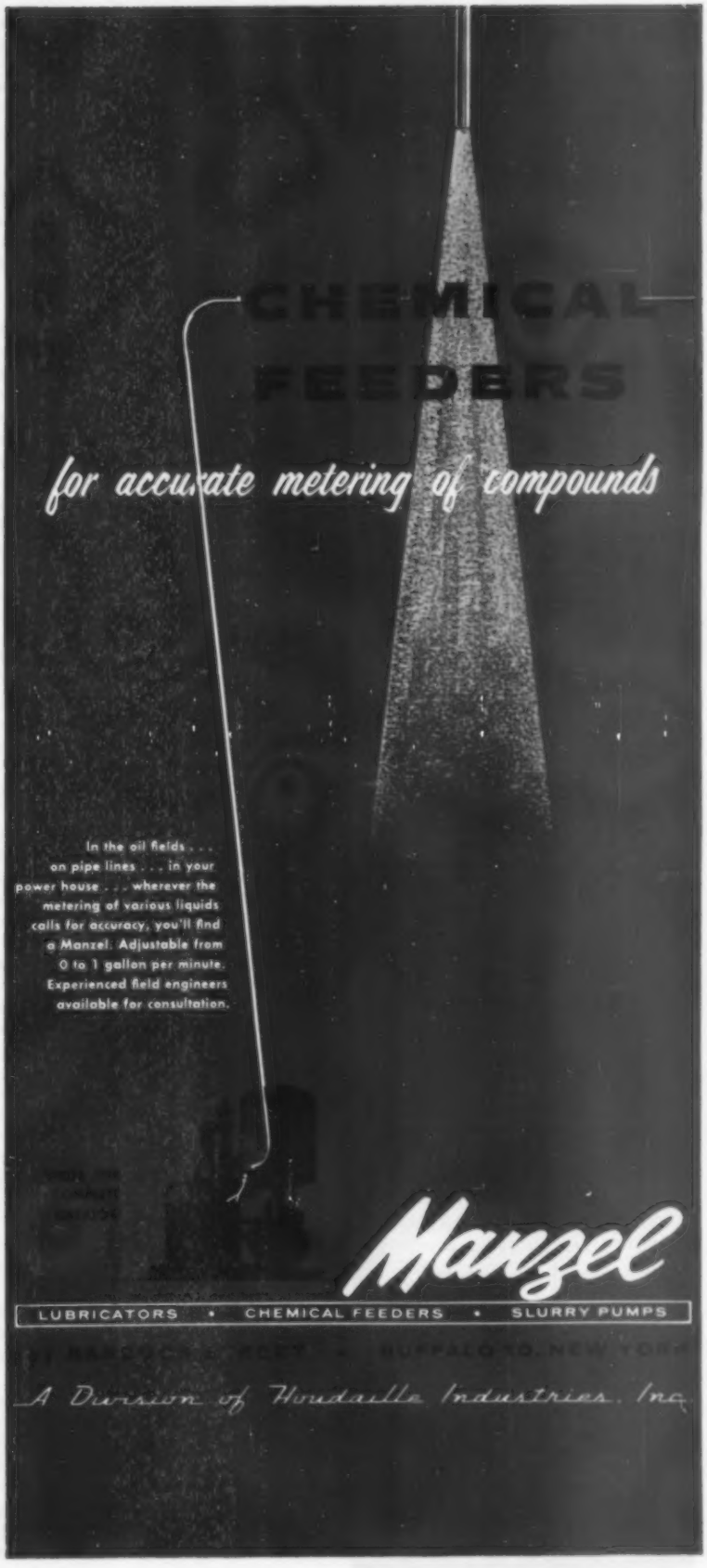
"We are very slow and timid about mastering the new method of intensified oil extraction by hydraulic seam fracturing. Hydraulic fracturing has been used at comparatively few Tuimaza wells."

Kuvykin also criticized delays in exploiting the new Shkapovsky field, which he described as close to the prolific Tuimaza field in size. He said oil and construction ministry officials have been too slow in building pipe lines, water mains, other production installations and housing in the area.

Turning to drilling, the Bashkir Oil Federation director stated that "thanks to extensive use of turbine drills" the speed of operational drilling has doubled and exploratory drilling speed has increased 158 per cent during recent years.

"In 1954, 130 wells were drilled at a speed exceeding 1000 meters per rig per month, and at seven wells the drilling speed was more than 2000 meters per month. However, drilling speeds for Bashkir republic crews as a whole are still too low, averaging about 535 meters per rig per month in 1954.

"Our great amount of technical equipment, plus the inflexible will of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our oil workers to complete their assignments ahead of schedule, give us the basis for reducing the time for drilling operational wells to 35 to 40 days and exploratory wells to 100 to 120 days."

Drilling Troubles

Kuvykin reported that "major shortcomings in the organization of drilling operations" are responsible for unproductive expenditures of time and excessive costs in drilling.

"Crews are idle for long periods because the Sterlitamark Cement Plant does not supply them dependably. Much time is lost waiting for cement, lumber, tools and casing, prompt delivery of which still troubles the Bashkiria Oil Industry Technical Supply Trust very little. Power personnel often disrupt the work of drilling crews.

"Breakdowns in drilling have been reduced somewhat as compared with the past year, although they continue to be high in number. The drilling trusts and offices are not really combating breakdowns or dealing with people who cause them.

"One of the reasons for the high breakdown rate is that a number of drilling crews are unqualified. Chief engineers of the drilling trust and offices, especially in exploratory work, do not pay serious attention to improving the technical training, correct selection and placement of drilling personnel.

"In the Western Bashkiria Oil Prospecting Trust, 137 out of 270 drillers are not authorized to engage in drilling operations. At the same time we have young specialists who are being used as common laborers.

"High unproductive expenditures are caused by so-called 'windows' in drilling. After finishing one well, the crew does not begin drilling the next one right away, often waiting quite a long time. This is because derrick construction and installation methods lag behind the growing productivity of drilling crews.

"We can make the 'windows' in drilling smaller by using new technology and introducing large-block assembly of derricks and auxiliary equipment."

Kuvykin said that frequent changes in drilling crews also cause considerable trouble.

"Just when people get used to their jobs and to each other, they are shifted elsewhere. This causes real damage to increased labor productivity.

"Our drilling operations are being expanded chiefly through exploratory drilling and structural test drilling. It is here, however, that shortcomings are most often encountered.

"The work of the Eastern Bashkiria Oil Prospecting Trust is especially unsatisfactory. Drilling operations are badly organized there; discipline is loose; and potentialities are not realized. Comrade Yefremov, the director, and other trust officials have let matters drift."

Predicts Cost Cut

A Tatar republic official, Z. I. Muratov, also speaking before the Twentieth Communist Party Congress, voiced much the same criticism of petroleum industry development in his area. He predicted that the unit cost of oil will be reduced 25 per cent in Tataria under the Sixth Five-Year Plan and said that the use of natural gas will increase 10 times. But he added:

"There are still many difficulties and shortcomings in our work. Tremendous amounts of oil well gas are as yet unused, and advanced work methods are slow in being introduced.

"The rate of increase in petroleum output is already being held back by a lag in building such important oil production links as power plants and lines, industrial water supply, machine shops, repair facilities, roads, housing and cultural and service facilities.

G. Sokolov, assistant director of the Tatar Oil Federation, reported that construction work in Tataria is increasing at less than half the rate of oil extraction. He said that construction organizations will have to double their personnel and building materials plants will have to triple their capacity if they are to provide the necessary volume of production, housing and service facilities. * * *

Appraisal Survey

A thorough financial and operational summary has been collected by John S. Herold, Inc., on 90 oil and gas companies.

The companies covered in the survey are appraised at an aggregate sum of $55 billion. Their domestic producing properties count for about 70 per cent of the nation's crude reserves and about 65 per cent of its gas reserves. On a world-wide basis, they own directly or indirectly about 80 per cent of the world's crude oil reserves. The remaining 20 per cent is distributed among a few governments, many public and privately owned companies and in the U.S.A. and Canada among individual lease and royalty owners.

There are two sections to the study. Section one covers outline of each of the 96 companies giving the physical and economic features of each concern. Section two measures the December, 1955, common stock prices of the companies in terms of their earning power and appraisal work.

The manual is $30 and may be obtained from John S. Herold, Inc., 230 Park Avenue, New York 17, New York.

PERSONALS

▸ Two top American industrialists, **L. F. McCollum,** Houston, Texas, and **L. L. Colbert,** Detroit, Michigan, will address oil men attending the thirty-seventh annual meeting of the Texas Mid-Continent Oil & Gas Association in Houston, October 2-3.

L. F. McCollum

L. L. Colbert

McCollum, president of Continental Oil Company, and Colbert, president of Chrysler Corporation, both grew up in Texas.

McCollum joined Conoco as its president in 1947. He began his oil career with Humble Oil & Refining Company in 1925 as a geologist and was coordinator of all Jersey Standard production activities prior to joining Continental.

President of Chrysler Corporation since 1950, Colbert is the first Texan to head one of the automotive "Big Three." He became resident counsel for Chrysler in Detroit in 1929.

▸ **Herman J. Schmidt,** associate general counsel, has been elected general counsel of Socony Mobil Oil Company, Inc. In that position, he succeeds **Austin F. Foster,** general counsel since 1948 and a member of the board since 1955.

Foster continues as a member of the board, with the office of the general counsel among the departments in his portfolio. Succeeding Schmidt as an associate general counsel is **John J. Scott,** who has been an attorney with the company since 1945.

▸ Six scientists have joined the staff of the Ohio Oil Company's research center at Denver, Colorado.

The additions are **Dr. Lloyd C. Pray** and **Dr. Donald R. Baker,** research geologists; **Dr. John L. Ellingboe, Dr. William S. Ferguson,** and **Dr. Charles J. Norton,** research chemists, and **Dr. Alvin L. Benham,** research engineer.

▸ **Dr. James A. Tong** and **H. R. Moorman** are newly elected president and executive vice president, respectively, of Socony Mobil Oil Company de Venezuela.

Relinquishing the presidency of the Venezuelan affiliate is **John C. Case,** a director of the parent company and its vice president in charge of producing.

▸ **Maurice B. Parmelee** has been elected secretary-treasurer and a member of the board of directors of Sun Oil Company, Ltd. At the same time, **John C. Agnew** was elected assistant secretary-treasurer, and **Frank R. Markley** resigned as a member of the board but will continue as vice president.

Parmelee was formerly office manager of the general sales department of the parent Sun Oil Company and has been a Sun employee more than 24 years. Both Markley and Agnew are officers and board members of Sun Oil, Markley being vice president in charge of marketing and Agnew secretary-treasurer.

▸ **Duncan Neblett,** general counsel of Eastern States Petroleum Company, Inc., has been elected vice president of the company.

Neblett was first associated with Eastern States in 1943 as an attorney and the following year was elected director and vice president, in which position he continued until 1947, when he entered private practice. He rejoined Eastern States in 1951 as chief attorney.

Edward A. Kapelka was elected treasurer of the company. He first joined Eastern States in 1939 as office manager and was assistant treasurer before his recent promotion. Kapelka succeeds **Theodore H. Grobe,** treasurer since 1945. Grobe will continue his association with Eastern States in an advisory capacity.

▸ **Robert W. Richards** has been named division attorney for Magnolia Petroleum Company, with headquarters at Oklahoma City, Oklahoma. Richards has been with the company for 14 years.

Wendell J. Doggett, former member of the Oklahoma City legal staff, is being transferred to Dallas, Texas, where he will become a part of Magnolia's legal department at its general offices. Doggett has been with the company for the past 8 years.

A new member of Magnolia's legal staff in Oklahoma City will be **Sidney M. Groom Jr.,** formerly manager of offshore operations for the Department of the Interior at New Orleans, Louisiana.

▸ **Boone Macaulay** has been named to the newly created position of assistant to the vice president and general manager of the domestic and foreign crude production department of Atlantic Refining Company.

Since 1954, Macaulay has been manager of the domestic production administrative division. He joined Atlantic's accounting department in 1934. Succeeding him is **Clarence E. Cardwell Jr.** Cardwell, an Atlantic employee since 1947, was formerly assistant to the manager for the West Texas-New Mexico region.

▸ **Charles Leslie Rice Jr.,** vice president and head of the oil and natural gas department of The Empire Trust Company, New York City, has been elected a director of the bank.

Rice is a trustee of Cuban Venezuelan Oil Voting Trust, and a director of many companies in the oil and gas field.

▸ **J. H. Loudon** has been elected a member of the board of directors of Shell Oil Company. Loudon has served with various affiliated and associated companies throughout the world, and now is general managing director of Royal Dutch Petroleum Company and chairman of the board of Shell Caribbean Petroleum Company.

Loudon replaces **Dr. H. Bloemgarten** on the Shell Oil board. Dr. Bloemgarten, who has retired, served as a vice president of Shell Oil prior to 1947, when he became a director of the company and a managing director of Royal Dutch Petroleum.

▸ **Booth Kellough** has been appointed divisional attorney for Gulf Oil Corporation in the newly established law office of the corporation in Denver, Colorado.

Formerly a lawyer in Gulf's Tulsa, Oklahoma, office, Kellough in his new position will be responsible for the handling of legal affairs in the newly created production division in Denver.

Officers of Association of Desk and Derrick Clubs for 1957 are: Florynne T. Brandon, Houston, Texas, treasurer; Betty Todd, Brinkerhoff Drilling Company, Denver, Colorado, second vice president; Maxine Hacke, Warren Petroleum Corporation, Tulsa, Oklahoma, first vice president; Lavada Clayton, Gulf Oil Corporation, Wichita Falls, Texas, secretary; Irma Cline, Nelson, Montgomery Robertson & Sellers, Wichita Falls, Texas, president. They were elected at the annual convention in New Orleans September 8, 1956.

Directors for 1957 are: Region (1) Eunice Wilder, New York (2) Ann Pringle, Detroit, Michigan; (3) Judith Hathaway, Atlanta, Georgia; (4) Gladys Watford, Houston, Texas; (5) Katherine Nabours, Abilene, Texas; (6) Helen Little, Oklahoma City, Oklahoma; (7) Polly Lamkin, Denver, Colorado; (8) Lois Lewis, Los Angeles, California.

Personals

W. L. Butte and **R. E. Mays** have been elected members of the board of directors of Creole Petroleum Corporation, with headquarters in Caracas, Venezuela. They replace **M. E. Jones** and **W. A. Greeven,** who have resigned to accept positions with the parent company, Standard Oil Company (New Jersey).

Also announced was the election of **D. E. Stines** as a vice president of the New York office. Stines will replace **N. J. Campbell Jr.,** who is leaving Creole to join the law department of Jersey Standard.

Harry S. Phillips, Great Lakes district representative of the Oil Industry Information Committee, based in Chicago, Illinois, joined the OIIC Middle Atlantic district staff in Philadelphia, Pennsylvania.

Robert E. Harris, OIIC Minnesota-Dakotas district representative in Minneapolis, Minnesota, moved to Chicago to replace Phillips. **Stuart G. Baird Jr.,** formerly bureau chief for the International News Service in Miami, Florida, and staff member of the Minneapolis *Star and Tribune*, is now a member of the staff of the Minnesota-Dakotas district replacing Harris.

John E. Mecom, independent oil operator of Houston, Texas, has been elected a director of Reed Roller Bit Company.

Virgil P. Cline, formerly with The California Company at New Orleans, Louisiana, has been transferred to Denver, Colorado, as western division attorney. He will act as legal advisor for the company in Colorado, Wyoming, Montana, the Dakotas, and western parts of Kansas, and Nebraska.

Elmer R. Erickson has been elected president of Northwestern Refining Company. He was executive vice president and secretary before his recent promotion.

W. C. Lane has been appointed manager of the foreign department of Standard Oil Company of California. He had been assistant manager of the department for nearly 30 years.

Rear Admiral Carl G. Drescher, former director of the Armed Services Petroleum Purchasing Agency, has been appointed assistant director of foreign operations of Sinclair Oil Corporation.

Admiral Drescher served for a number of years in various petroleum posts with the Navy. In 1948, in the organization of ASPPA to consolidate all petroleum procurement and distribution for the Army, Navy, and Air Force, he became that agency's first director.

J. Earle Gray was appointed assistant general manager of Tidewater Oil Company's western division, with headquarters at San Francisco, California. In his new assignment, Gray will assist in conducting and coordinating all drilling, refining, marketing and transportation activities of the company in the seven western states and Hawaii.

DEATHS

Leon F. Russ Jr., 38, San Antonio, Texas, oil man, died September 14 at Port Aransas, Texas. He was vice president of the Russ Oil Corporation. Russ attended the University of Texas and Southern Methodist University.

R. G. "Peg" Whealton, 58, petroleum consultant, died August 24 at Huntington Memorial Hospital, Pasadena, California. A member of the WOGA Wildcat Committee, Whealton began work as a petroleum consultant in 1945 upon termination of his war duties with the government as Director of Production for Pacific Coast District 5. He was graduated from Stanford University in petroleum engineering. For a number of years, he served in various capacities with oil and service companies in the San Joaquin Valley and Los Angeles Basin.

Charles E. Wilcox, 89, veteran oil man, died recently. Wilcox was born in Oil City, Pennsylvania, and spent more than 70 years of his life in the oil industry. He is credited with drilling the first producing well in Utah and with perfecting several tools which improved drilling facilities.

Don C. Ellswood, 49, manager of commercial and industrial sales of Southern Counties Gas Company since 1946, died August 23 in a Santa Monica, California, hospital. He had been under a doctor's care for several months. A graduate of Iowa State College, Ellswood joined Southern Counties in 1935, following a business career in the Midwest.

O. N. Andrew, sales manager for BJ Service, Inc., was killed in an automobile accident near Casper, Wyoming, on August 8. Andrew, who joined BJ Service in 1944 as superintendent of shooting, served as wire line supervisor and Pacific Coast division manager before becoming sales manager for the company.

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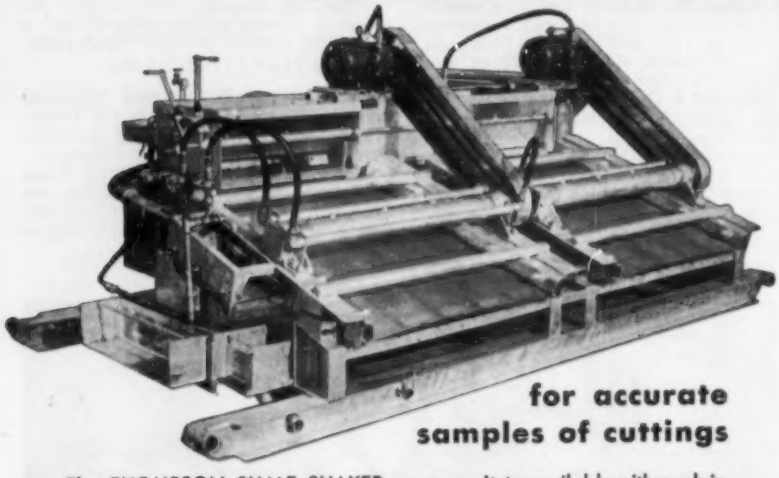

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LAUGH with BARNEY

Mrs. McTavish looked out the window as the family was going in to dinner and wailed, "Och, Jon, here comes company, and I bet they haven't eaten yet."

"Quick!" ordered the Scotsman. "Everybody out on the porch with toothpicks."

Worried man to psychiatrist: "All day long I eat grapes."

Psychiatrist: "So what? Lots of people eat grapes."

Worried man: "Off the wall paper?"

A traffic expert said recently that if all the cars in the nation were placed end to end, some fool would pull out and try to pass 'em.

Truck Driver: "Looka here, gal, this coffee tastes like mud."

Waitress: "Well, it was ground this morning."

Even a mosquito doesn't get a slap on the back until he starts working.

Seventeen people from a shipwrecked vessel escaped in a life boat which was built to hold only 14 persons. The captain asked for three volunteers to jump overboard to save the rest of the victims from drowning.

A little Frenchman stood in the back of the boat, bowed, shouted, "Vive la France," and jumped overboard.

After a moment of silence an Englishman arose. "There'll always be an England," he said as he jumped into the ocean.

Several moments passed. Finally a tall Texan stood up and drawled, "Remember the Alamo." With that he picked up the Mexican next to him and tossed him overboard.

"Is Frank a confirmed bachelor?"

"He is now. He sent his picture to a lonely hearts club, and they sent it back with a note saying, 'We're not that lonely.'"

The young man's parents were objecting to their son's choice of a girl friend.

"But gee, dad," said the boy, "she's the best girl I can get with the car we've got."

"Is the world round?" the teacher asked the boy.

"No, ma'am."

"Is it flat, then?"

"No, ma'am."

"Are you crazy, child? If it isn't round and it isn't flat what is it?"

"Pop says it's crooked."

Girl's father: "Young man, we turn the lights out here at 10 p.m."

Boyfriend: "That's okay. We won't be reading."

John: "Daddy, what does it mean when the paper says someone went to the convention as a delegate-at-large?"

Father: "It means he went without his wife, son."

"I hear you have accepted Frank. Did he happen to mention that he had proposed to me first?"

"Not specifically. He did say he had done a lot of foolish things before he met me."

The prisoners in the penitentiary rioted and barricaded themselves in a cell block. Perplexed, the guards tried every way to coax them out. Fnally, the warden, with a smile of relief, suggested: "Offer them time and a half."

A Soviet worker left the factory every night pushing a wheelbarrow full of loose straw. Every night the guard halted him and carefully searched through the straw but found nothing and passed the worker through the gate.

This performance was repeated night after night, and after a month. the guard broke down and pleaded with the worker to explain things to him. "I'm going to be sent to the Urals, so you can talk freely to me. I give you my word I won't tell. But I'm curious — what are you stealing?"

"Wheelbarrows," the worker confessed.

"So you want another day off," snorted the office chief to his small office boy. "I'm anxious to hear what excuse you have this time. You've been off for your grandfather's funeral four times this year already."

"Today my grandma's getting married again," said the youngster.

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Who cares how empty her head is, so long as her sweater fits?

* * *

"Miss Jones," said the exasperated professor, "the quotation is, 'All men are created equal,' and not, 'All men are made the same way.'"

* * *

Father: "Johnny, what makes you skip school all the time?"
Johnny: "Class hatred."

* * *

"Son," said the sultan, "when I was your age I'd made a million."

* * *

A modern business firm hired a psychologist as personnel manager who began by hiring a new secretary. The boss was looking on while the expert gave a psychological quiz to three feminine applicants.

"Two and two," said the psychologist.

"Four," replied the girl promptly.

To the same key words, the second girl said, "It might be 22."

The third girl answered, "It might be four and it might be 22."

After the last girl left, the expert turned to the boss. "There you have the perfect example of the efficient psychological way of hiring people. The first girl said the obvious thing. The second was suspicious. The third was cagey and wasn't going to get caught. Which do you prefer?"

The boss didn't hesitate. "I'll take the slick looking blonde with blue eyes."

* * *

Stranger: "I came in because I read your ad for a man to retail canaries."
Proprietor: "Oh, do you want the job?"
Stranger: "No, but I'm curious—how did the canaries lose their tails."

* * *

A lady traveling down South saw for the first time a fig tree.

"Can you tell me," she asked her guide, "what kind of a tree that is?"

"A fig tree, ma'am," was the answer.

"But it can't be a fig tree," observed the lady.

"But it is a fig tree, ma'am," insisted the guide.

"Humm," mused the lady. "I always thought its leaves were larger than that."

* * *

A married man we know quite well relaxed on a recent business trip by enjoying a lively weekend with a lively blonde. Not long after returning to the home office, however, a rather shifty individual paid him a visit and said, with the nasty innuendo of a professional blackmailer, "Remember that trip you took? Remember that blonde?" The answer to both questions was "Yes."

"Well, mister," said the unsavory one, "it just so happens that I have photographs of everything what you and her did."

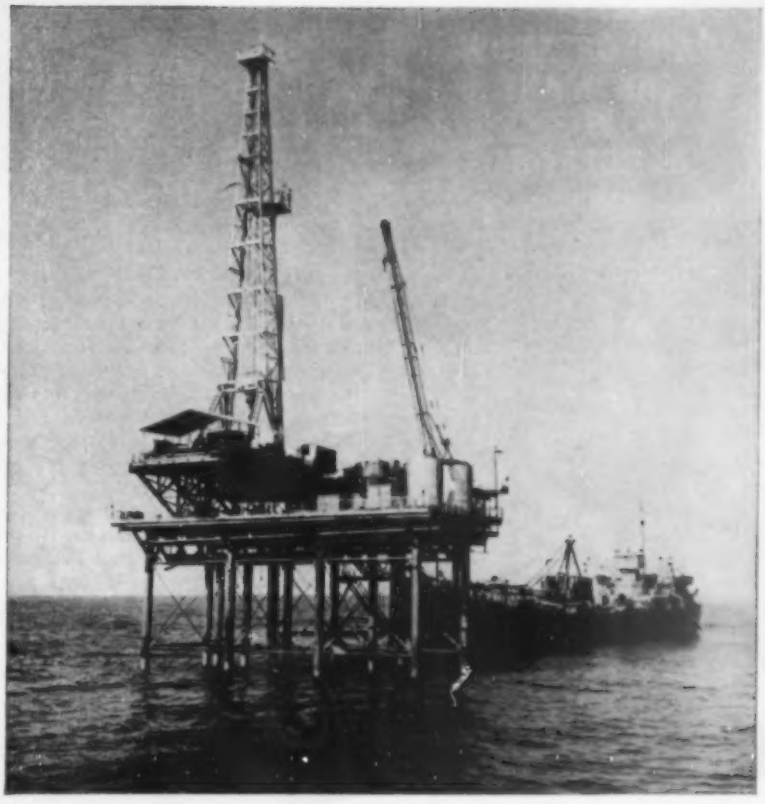
"Everything?" gulped our friend.

"*Everything?* See?" He spread a half dozen highly detailed snapshots on the desk and after giving them a chance to make the proper impression, asked, "What are you gonna do about it, mister?"

"Well," drawled our friend cooly, "I'll take one of those, and five of this one over here. Can I have them tinted?"

* * *

Then there was the geologist who had a hobby of collecting stones and putting them in his bathroom. He had rocks in his head.



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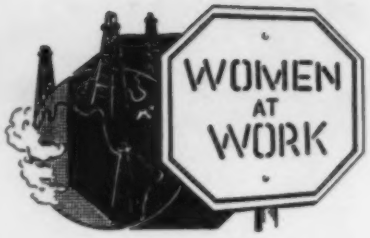

Loves Switzerland

D. Marjorie Mott, a Kansas oil girl, is now in Zurich, Switzerland, serving as secretary to Jack H. Heathman, manager of Molasse Oil Exploration Company. Previously she was in charge of the land department and Heathman's sceretary in Wichita, Kansas, with Heathman-Seeligson Drilling Company.

In the oil business for 10 years, Marjorie began her career with the H H & B Drilling Company, Inc. Following the company's sale in 1947, one partner, Heathman, formed his own company, and she has since been associated with him.

A graduate of the Wellington, Kansas, high school, she attended Kansas State Teachers College, a business school in Wichita, and enrolled in a lecture course in geology in conjunction with her work. Prior to entering the oil industry, she was a secretary for an insurance firm, and secretary in the legal and contract department of the Midwestern Procurement Division of the Army Air Force in Wichita.

Currently Marjorie has taken an apartment in Zurich and advises she is enjoying her stay in Switzerland very much. She reports the people are most interesting, helpful and gracious, and make up for her lack of German and French as they do so well in English.

D. Marjorie Mott

Traveling has always been topmost in Marjorie's outside interests, with other trips to points of interest in Mexico, Canada and the United States. Besides traveling, she enjoys cooking, sewing, and entertaining her friends. Marjorie has taken advantage of a number of self-improvement courses, including the Dale Carnegie course in "Developing Courage and Confidence, Effective Speaking, Leadership Training, and Human Relations."

She is an active member of the Oil Secretaries Association of Wichita, which she served as president in 1948.

Oil Family Affair

Being raised in the Southern Oklahoma oil area and having a father in the industry culminated into an oil career for Doris Stuckenburg. Add hours of study, desire to have pride in her job, and you find a person very valuable in the production and geological departments of the Samedan Oil Corporation, Ardmore, Oklahoma.

Doris Stukenburg

Following graduation from high school, Doris joined the Rockland Oil Company, assuming bookkeeping and secretarial duties. During the war she accepted an assignment with the American Red Cross, serving in the Pacific as an auditor and supervisor of accounting records. During this period she worked in Hawaii, New Caledonia, Philippine Islands, Japan, Guadalcanal, Guam, Korea, Australia, New Hebrides, Shanghai, Tienstin, China, Okinawa and Kkajalien. One leave found her on a busman's holiday touring Hong Kong, Bangkok, Calcutta and New Delhi.

Returning to this country in 1950, Doris joined the Samuel Roberts Noble Foundation, later transferring to her present post with Samedan. Her enthusiasm for the oil industry encouraged her brother to study petroleum engineering and it was a proud moment for her when his thesis won a first prize offered by one of the major companies.

Active in the Ardmore Desk and Derrick Club, Miss Stuckenburg is also a member of the Business and Professional Women's Federation Club, and has maintained an enthuiastic interest in international relations. Many civic clubs in Ardmore and Dallas have enjoyed her vast collection of colored slides.

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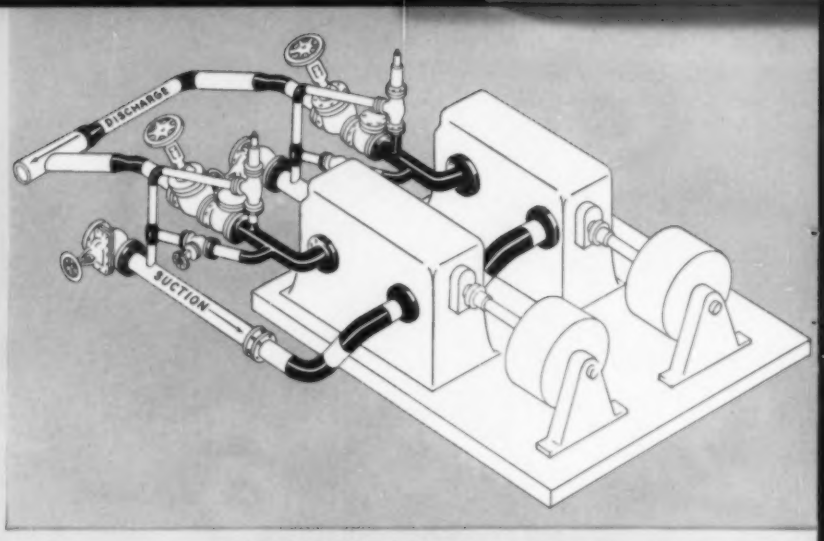

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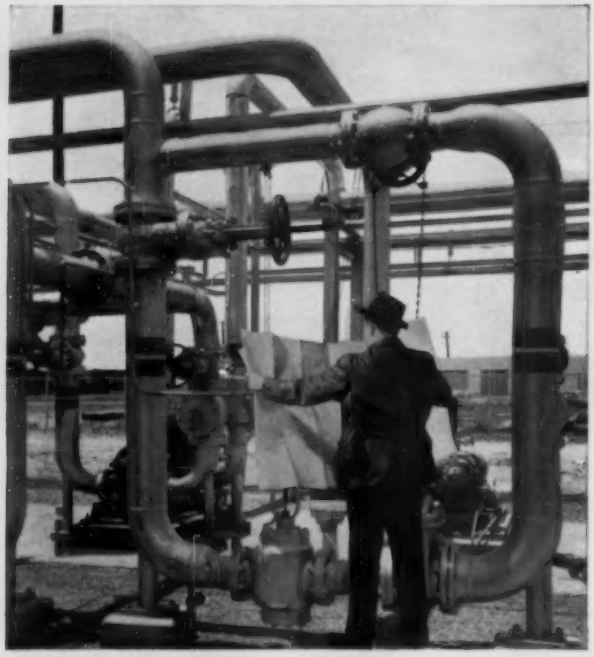

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TUBE TURNS

A DIVISION OF NATIONAL CYLINDER GAS COMPANY

LOUISVILLE 1, KENTUCKY

OIL and GAS TRADE NEWS

Company Sales, Mergers Take Spotlight

FOCUSED in the spotlight of this month's news are sales and mergers of numerous companies.

Latest firm to become one of the Dresser Industries is The Guiberson Corporation of Dallas, Texas. This makes the eleventh in Dresser's group of oil, gas, and chemical equipment companies. Guiberson's assets were acquired for a reported consideration of 110,000 shares of Dresser common stock, believed to be worth $9,377,500.

Gordon Guiberson of La Jolla, California, president of the Guiberson firm, will be a member of Dresser's board of directors and will remain as head of his company.

Stauffer Chemical Company has purchased Harshaw Chemical Company's interest in their two jointly owned chemical companies—New York-Ohio Chemical Corporation and Nyotex Chemicals, Inc. Previously, Harshaw had acted as sales agent for both New York-Ohio and Nyotex except for the West Coast, which was covered by Stauffer.

Accounts of the Lemont Chemical Company of Lemont, Illinois, have been acquired by Solvent Service, Inc., specialists in chemical and hydraulic cleaning and descaling of industrial equipment.

Announcement of the liquidation of LeBus Rotary Tool Works, Inc., and organization of two new LeBus companies has been made. LeBus International Engineers, Inc., one of the new companies, will be a LeBus-owned corporation, while the other, LeBus Manufacturing Company, will be a wholly owned subsidiary of the American Hoist and Derrick Company of St. Paul, Minnesota.

American Hoist acquired the LeBus plant and facilities at Longview for the manufacture of LeBus drop-forged truck tools and wire line accessories. An expansion program is also planned.

As a result of another merger, Bowen-Itco is the name of a new company formed by the combining of two Houston, Texas, firms — Bowen Company of Texas, Inc., and Itco International, Inc.

In the former associated arrangement, Bowen Company of Texas manufactured Bowen and Itco tools and distributed them domestically. Itco International marketed Itco and other product lines for the export trade.

Three companies have joined forces to form National Services, Inc., in order to supply drillers with the four coordinated services of mud, diamond coring, core analysis, and drill-stem testing from one source. National Testers, Inc., National Mud Service Company, and National Cores, Inc. are the companies participating in the merger. J. Fred Hill and Ken Kendricks, are president and executive vice president respectively of the new corporation.

The Maloney-Crawford Tank & Manufacturing Company of Tulsa, Oklahoma, pioneer manufacturers of bolted and welded steel tanks, oil and gas separators, emulsion treaters, dehydration units, and pressure vessels, has been purchased by H. M. Byllesby and Company of Chicago, Illinois.

This announcement was made jointly by S. P. Wallace, president of Maloney-Crawford and J. H. Briggs, president of Byllesby and Company. Management, personnel, and policies of Maloney-Crawford will be maintained.

Acquisition of Englehart Manufacturing Company of Davenport, Iowa, by Caterpillar Tractor Company has been announced.

The Davenport company has been a major supplier of parts for Caterpillar for the past 13 years.

In making the acquisition, Caterpillar issued 20,000 shares of its common stock for all of the capital stock of Englehart. The company will be operated as a wholly owned subsidiary of Caterpillar.

No major changes of organization or operations are contemplated as a result of the acquisition. C. E. Murray, president, will continue to be chief administrative officer of Englehart.

H. K. Porter Company, Inc., acquired, as of October 1, the business of West Virginia Steel and Manufacturing Company, Huntington, West Virginia.

Tracerlab Neutron Generator

Continuing its development of a neutron generator, a project that has been under way for many years, Tracerlab is now directing the design of this device toward its use in oil well logging.

By generating useful quantities of 14 MEV neutrons by means of Tracerlab's improved discharge tube, on which patents are pending, surrounding formations can be made radioactive for short periods of time, a process heretofore not possible except with very cumbersome apparatus. By measuring the kind and intensity of radiation produced, oil well geologists can determine what materials are in the surrounding strata and can detect the presence of such things as gas, oil and brine.

New Kennametal Facility

Kennametal, Inc., has announced purchase of a 1200-acre tract of land near Latrobe, Pennsylvania, for the expansion of manufacturing facilities.

This installation will provide about 25,000 sq ft of floor space and will be utilized for grinding and finishing of special or custom-fabricated carbide products. This unit is expected to be in production by the end of the year.

$9,000,000 Expansion Program

A $9,000,000 building and tooling program for LeTourneau-Westinghouse Company has been announced.

Major aspect of the program is the building at Peoria, Illinois, of a 300,000 sq ft modern factory building to adjoin the present site of one of the plants. Cost will be more than $6,000,000, with completion scheduled for April 1, 1957.

Simultaneously, the company is expanding its plant operations at Toccoa, Georgia, and at Indianapolis, Indiana.

This additional building space and machine tools will provide more than double the productive capacity of LeTourneau-Westinghouse Company since its organization in 1953.

Rights Grant to Lummus Devices

Thermal Research & Engineering Corporation has been granted exclusive rights to manufacture and sell high-intensity combustion devices developed and patented by The Lummus Company.

Equipment involved in the licensing agreement centers about a patented Lummus combustion device that provides high-intensity, clean combustion with all grades of refinery gas and petroleum products. It is said to be especially effective in the very large heat producing capacities above 10,000,000 BTU per hour and with the use of residual fuels, including tar and asphalt. The Lummus design complements Thermal's own line of burners.

Dravo Announces Scholarships

Eight awards in Dravo Corporation's annual $12,000 college and university scholarship program for 1956-57 have been announced.

New scholarships, totaling $1500 each, have been granted to four junior students: Robert Gerald Hoppe, Elgin, Illinois, mechanical engineering student at Carnegie Institute of Technology; Duane Thayer Heineman, Springbrook, New York, civil engineering, Cornell University; Peter Robert Schulz, New Milford, Pennsylvania, mechanical engineering, Lehigh University; and Arthur Warren Bissell, Beaver, Pennsylvania, business administration, University of Pittsburgh.

Second-year scholarships of $1500 were awarded three college seniors who received first-year awards in 1955. They are George Martin Fuls, McKeesport, Pennsylvania, mechanical engineering, Carnegie Institute of Technology; Douglas Hall Merkle, Darien, Connecticut, civil engineering, Cornell University; and Alfred Dean Bartlett, Pittsburgh, Pennsylvania, business administration, University of Pittsburgh. A fourth senior award was given to Richard P. Romer, Scranton, Pennsylvania, mechanical engineering student at Lehigh University.

Two deck sections of a 133 ft by 112 ft, self-contained, offshore drilling platform to be installed in 90 ft of water are shown loaded out on barge in Todd Shipyards, Houston, Texas. Unit was recently completed by Todd Shipyards Corporation for offshore Louisiana use for J. Ray McDermott & Company, Inc.

Beckman Completes New Building

Berkeley division of Beckman Instruments, Inc., has completed the $500,000 building program initiated last October, more than doubling the size of the Richmond, California, facilities.

Extensive remodeling of the existing plant plus a new, 55,000 sq ft building provide 100,000 sq ft of working space.

General Offices for Youngstown

The Youngstown Sheet and Tube Company is planning to build a modern, three-story general office building at Youngstown, Ohio.

It will be constructed on a 52-acre plot and should be ready for occupancy late in 1957. The building will be completely air-conditioned and have a total floor area of approximately 183,000 sq ft. In addition to service elevators, there will be escalators connecting all floors.

Architects for the new building are Garfield, Harris, Robinson, and Schafer of Cleveland, Ohio.

Companies Set Up Joint Efforts

C. W. Nofsinger Company has entered into an agreement with the Long Construction Company of Kansas City, Missouri, to handle overall design and construction of petroleum and chemical plants.

Such projects will be performed under the name of the Nofsinger-Long Company. Both the Nofsinger company and Long Construction will operate separately otherwise.

Magcobar Now in Venezuela

Magcobar de Venezuela, C.A., a new Latin-American affiliate of the Magnet Cove Barium Corporation, one of the Dresser Industries, has been organized in Puerto la Cruz, Venezuela.

The new Venezuelan corporation will include mining, processing, and distributing facilities for the marketing of Magcobar's oil well drilling mud additives. Already under construction is a processing plant in Pureto la Cruz, and another is projected for the Maracaibo region.

Heading up the company's activities as vice president is Mario Sanchez, Venezuelan businessman formerly engaged there in the transportation business. Willard Johnson of Houston, president of Magcobar, will also officiate as president of the South American company.

Ideco Opens Mexico City Office

Ideco, one of the Dresser Industries, has announced the opening of a new office in Mexico City.

G. W. (Jack) Walton, Ideco's executive vice president, at the same time announced the retention of Servicios Petroleros, E.I.S.A., as sales and service representatives for Ideco throughout the Republic of Mexico. To this firm will be entrusted the servicing of approximately 30 Ideco masts and rigs now in use or on delivery in that country.

Security Bits Made in England

Security Rock Bits, Ltd., Manchester, England, has begun full-scale production of the drilling bits developed in the United States by Security Engineering, one of the Dresser Industries.

The British company—control of which was purchased by Dresser last January—has been extensively retooled and is now supplying Security bits to the world markets. Previously, the company was known as Edeco, and manufactured rock bits under that trade name.

Dutch Affiliate for Badger

Badger Manufacturing Company and Comprimo N. V. of Amsterdam, Holland, announce the formation of a jointly owned subsidiary company, Badger-Comprimo N. V., with headquarters at The Hague, Holland.

This new firm will enable foreign affilates of the U. S. clients of Badger Manufacturing to obtain Badger services on other than a dollar basis and to take advantage of the European equipment manufacturing facilities.

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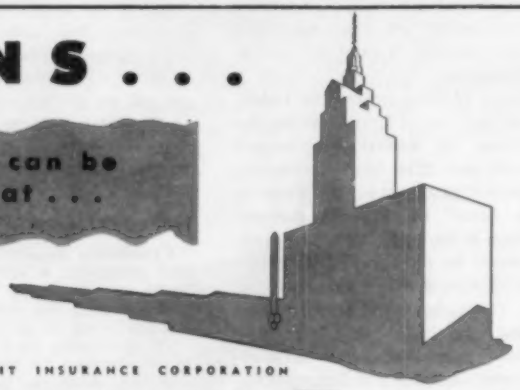

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NATIONAL BANK OF TULSA

The Oil Bank of America

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Trade News

J&L to Use Refining Processes

Jones & Laughlin Steel Corporation has announced plans for using advanced petroleum refining techniques for what is said to be the first time in the steel industry.

Refining facilities costing more than $2,000,000 will aid in the production of higher quality coal chemicals, which are used to make a wide variety of products.

Esso Research and Engineering Company has licensed Jones & Laughlin to use a sulfur-removal process called "Hydrofining." Universal Oil Products Company has licensed the steel firm to build a "Udex Process" unit for the final purification and removal of all remaining non-aromatic impurities.

The plants will be built at J&L's Aliquippa (Pennsylvania) Works. Construction is scheduled for completion early in 1957.

New Asbestos Cement Pipe Plant

Construction will be started soon by Johns-Manville Corporation on another Transite asbestos-cement pipe plant to be located at Denison, Texas.

The Denison plant will be J-M's seventh Transite pipe plant. Production, curing, storage, and shipping facilities will cover 350,000 sq ft located on a 400-acre tract.

Italian Firm Signs With Emsco

Stabilimenti Meccanici Di Pozzuoli of Naples, Italy, a firm of the Finmeccanica Group, has signed an agreement with Emsco Manufacturing Company for construction of oil well drilling rigs and component parts.

These rigs will be sold exclusively throughout the world by Continental Supply Company.

Western Supply Control Changes

Sale of the majority stock interest in Western Supply Company has been announced.

Controlling interest has been purchased by three oil industry figures, W. A. Baden, president of Anchor Petroleum Company; B. B. Blair, independent oil man, and L. F. Rooney, Muskogee and Tulsa, Oklahoma, industrialist. The company will continue to be operated by its present personnel and F. Wilson Dyes, former president, will act as chairman of the board and chief executive officer.

Western Supply was organized in Tulsa in 1907.

Now under construction: West Coast Transmission Line

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Trade News

Double Launching

Two new drilling tenders, "The J. W. Bates" and "The George M. Reading," were christened in a double ceremony recently at Orange, Texas. Built by the Levingston Shipbuilding Company, vessels represent the first venture in offshore drilling by the Reading and Bates Offshore Drilling Company. Units will permit drilling in the 20,000-ft range.

Kobe Pipe Division Sold

B & B Pipe and Tool Company announces the purchase of the pipe processing division of Kobe, Inc.

This, according to company officials, enlarges the scope of the firm and will permit functioning in a much wider variety of pipe operations.

E. W. "Al" Forrow is manager of the new division.

Rental Tool Company Formed

Formation of Land and Marine Rental Tools, with headquarters in Houston, Texas, has been announced by Olive Dorroh of Houston, vice president and general manager.

The new company is headed by Leonard W. Phillips of Shreveport, Louisiana, as president. Albert Sklar of Shreveport is secretary-treasurer. Another vice president is Alex Singer of Tulsa, Oklahoma, and assistant secretary-treasurer is R. H. Fleischaker, also of Tulsa.

Rockwell Opens Meter Lab

What is claimed to be the world's largest and most modern gas meter research and development laboratory has been opened by Rockwell Manufacturing Company at Du Bois, Pennsylvania.

This new department will permit Rockwell to run wear and endurance tests on diaphragms, complete meter mechanisms, and gears. A new salt spray unit will enable the company to run salt spray and humidity tests on different materials in order to determine the effects of atmosphere and salt spray on various parts used in its meters.

New Water Shut-off Service

The Chemical Process Company has announced a new service — Visqueez — for shutting off water encroachment in producing wells.

Visqueez is an oil-cement slurry in which the oil has been especially treated prior to mixing so that the cement will be carried to the deepest possible penetration, company officials say.

Either common or quick-set cement may be used. Temperature and pressure are said to have no effect on the efficiency of Visqueez, and the properties of the slurry are such that the usual high injection pressures are not required.

A companion service — CPC Kerosene Squeeze — is also available for use in conjunction with fracturing or acidizing treatments of producing wells.

Wedgeplug Valve Moves Operations

The Wedgeplug Valve Company, an affiliate of Stockham Valves & Fittings, has moved its entire operation to the Stockham plant in Birmingham, Alabama, in order to obtain larger production and other facilities.

All production and sales will be located at Birmingham.

Geophysical Magnetic Tape Plant

ORRadio Industries, Inc., will build what is said to be the nation's first plant designed expressly for the manufacture of magnetic instrumentation tape for the geophysical field.

The new $300,000 plant, to be constructed soon in Opelika, Alabama, will increase ORRadio's production facilities 400 per cent. Building is expected to be ready by mid-winter.

Plant will cover 37,000 sq ft on a 17-acre tract.

Midwestern Firms Open Branch

Announcement has been made of the opening of a new branch office and warehouse in Portland, Oregon, for Midwestern Pipe Line Products Company, Midwestern Engine & Equipment Company, Inc., and Midwestern Manufacturing Company, all of Tulsa, Oklahoma.

The new office will be headed by E. J. Spradlin as sales-service representative. Spradlin was formerly attached to the firm's Oklahoma City office.

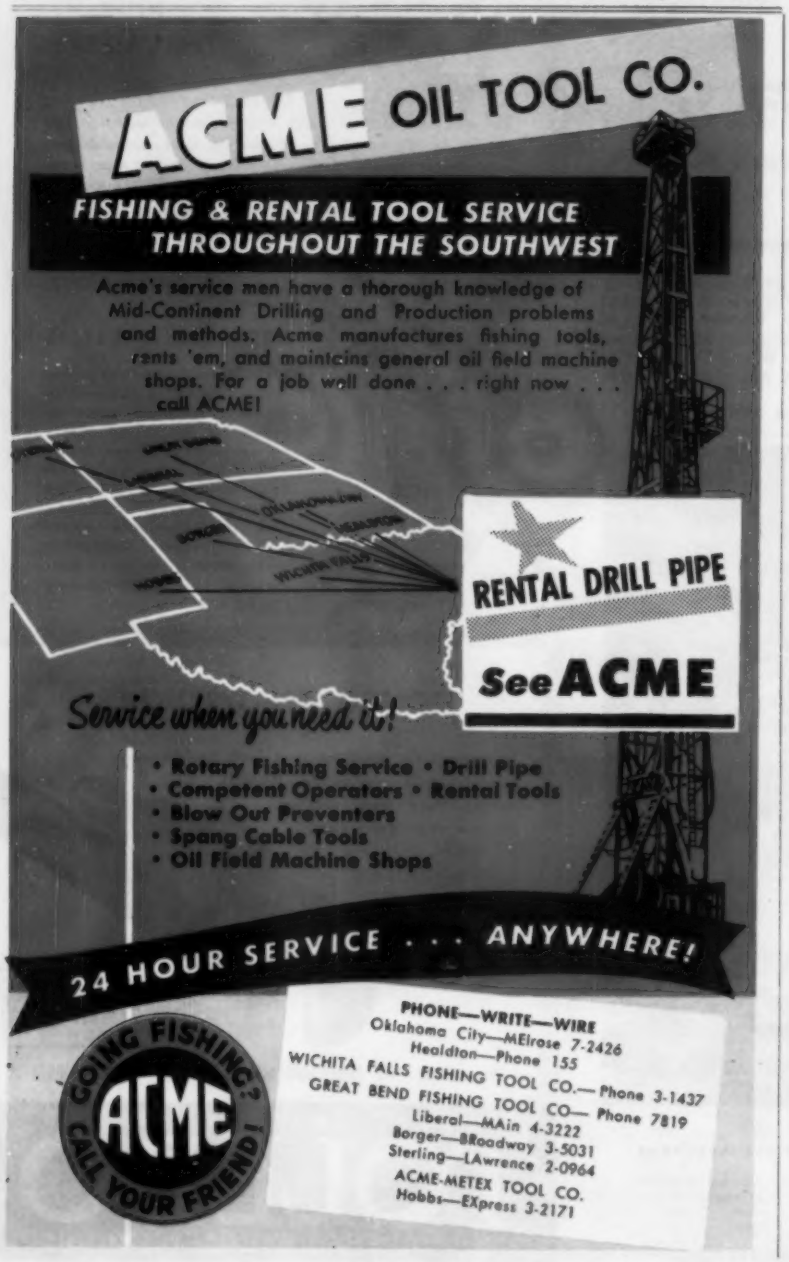
New Chemical Research Lab

An orange grove in Anaheim, California has been selected as the site for a completely modern research laboratory for United States Borax & Chemical Corporation.

The laboratory is being designed by Albert C. Martin and Associates, architects and engineers.

Future requirements have been provided for through the division of the building into four semi-separate segments, each housing a specific function.

Occupying an area of some 30,000 sq ft, the building will be of reinforced concrete construction. Completion is expected late in April, 1957, at an estimated cost of $850,000.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TRADE PERSONALS

R. G. Kelly

W. D. Owsley

▸ Two new executive positions and an executive change are announced by Halliburton Oil Well Cementing Company. The new positions are those of senior vice president.

H. P. Conroy

R. G. Kelly, formerly vice president in charge of field operations, and **W. D. Owsley,** formerly vice president for engineering advice to management, have been elevated to the posts of senior vice presidents.

Succeeding Kelly is **Harry P. Conroy,** formerly northern region vice president.

▸ **W. S. Sease** is now sales manager of the oil tool division of Chicago Pneumatic Tool Company, Fort Worth, Texas. He was formerly regional sales manager in the southeast section of Texas.

▸ Atlas Powder Company has announced the formation of a new sales development section in its explosives sales department. Heading the new section is **William T. Mahood,** formerly manager of the department's contractors section.

▸ Christensen Diamond Products Company has established a new Gulf Coast division, with offices in Houston, Texas. The division was formerly part of the Mid-Continent division.

The new division will be headed by **C. Ray Hudson,** who has been district manager in the Gulf Coast area.

C. R. Hudson

Claude Cox Jr.

Robert T. Barron will direct the Shreveport, Louisiana, district office, **Robert J. Dyar** the Houston, Texas, district, and **A. R. Adams** the Lafayette, Louisiana, district office.

The company also named **Claude Cox Jr.** as the new Mid-Continent division manager, with headquarters in Midland, Texas. Prior to his promotion he had served as district manager in Midland.

▸ **Elmer K. Stilbert** has been promoted to staff manager of coating materials for The Dow Chemical Company's plastic department. Stilbert served previously as assistant manager of coatings technical service.

▸ **Carra L. Lane** is the new president of Security Engineering Division, one of the Dresser Industries. Lane's appointment follows the promotion of **Ott Hammer** to operating vice president of Dresser Industries, Inc.

C. L. Lane

Ott Hammer

Hammer has been associated with Security since its founding in 1931 and has been president of Security since 1947.

Lane comes to the presidency of Security from his former post of vice persident and general manager of the Walker-Turner Division of the Kearney & Trecker Corporation in Plainfield, New Jersey.

WISCONSIN-POWERED

PIPELINE PADDING MACHINE

Cuts Costs... Protects Pipe

This machine is the product of M. J. Crose Mfg. Co., leading builders of wrapping and coating machines, tar heating kettles, pipe rolling rigs and many other types of pipeline equipment . . . utilizing Wisconsin Engine power wherever possible.

Dirt-padding of the bitumen-coated, wrapped pipelines under construction in rocky terrain is a time- and cost-saving technique, as handled by this unique piece of Crose equipment. In place of using sheet shielding or dirt-filled sack "breakies", this machine salvages available dirt from the rocky backfill of the spoil bank, conveys and spots it over the ditch, dropping the dirt alongside and over the pipe, as needed.

The rotating head at the end of an auger-type conveyor sorts and sifts dirt from the backfill spoil bank, screening out all material over 2-in. in diameter. A Wisconsin Model VG4D V-type 4-cylinder power unit, mounted on the hydraulically controlled boom, provides dependable, all-weather power for the padding machine which is handled by the tractor operator.

This is another oil-field assignment that calls for the rugged serviceability and the basic high-torque design of Wisconsin Heavy-Duty Air-Cooled Engines. The M. J. Crose Manufacturing Co., like many other leading builders of oil field and pipeline equipment, has used WISCONSIN Air-Cooled Engines as standard, original equipment almost since their inception. These builders know the score, based on performance records in the field and place their power bets accordingly . . . in favor of Wisconsin Engines. You can't do better than to specify "WISCONSIN POWER" for your equipment.

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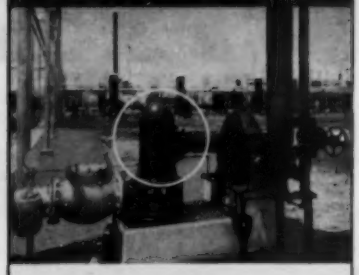

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The Johnson Right Angle Gear Drive has a wide application in oil and gas industries. The drive is used by refineries for Cooling Tower installations with steam turbine, internal combustion, or electric prime movers. In the vicinity of natural gas pipe lines many gas engine gear drives are in use for farm irrigation and municipal water supply.

Vertical or horizontal prime movers can be used with equal success in many applications. The advanced design of the Johnson Drive meets the exacting requirements of exposed operation . . . assures maximum service and safety with utmost economy and dependability . . either for standby, emergency or continuous 24 hour service.

The Johnson Right Angle Gear Drive is manufactured in a wide range of types, sizes and ratios . . . adaptable for dual, multiple or combination operation. Thousands in use throughout the world serving industry at low-operating cost and high efficiency. Catalog and full engineering data on request.

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Trade Personals

Robert O'Connell has been made service manager of the Findlay Division, Findlay, Ohio, of Gar Wood Industries, Inc. O'Connell was formerly associated with Clark Equipment Company as assistant service manager of the industrial truck division at Battle Creek, Michigan.

John W. McGovern has been elected executive vice president of United States Rubber Company, succeeding **H. Gordon Smith,** who has retired but will continue as a member of the board of directors.

McGovern was also elected vice chairman of the company's executive committee. He was elected a vice president in 1945 and a director and a member of the executive committee in 1951.

Robert Graves Hess has been elected executive vice president of the Walworth Company. Hess recently resigned as executive vice president of Pesco Products Division, Borg-Warner Corporation, to accept the Walworth position.

H. H. Kieckhefer has been named sales manager of the Wheelco Instruments division of Barber-Colman Company. He was formerly assistant sales manager.

W. C. Talbert

H. H. Kieckhefer

W. C. (Bill) Talbert has been appointed sales manager for Mission Manufacturing Company, Ltd., with headquarters in London, England. Talbert has been assistant export sales manager of Mission headquartered in New York City.

Appointments of an area engineer and two area sales representatives for the Canadian area have been announced by the Oil Well Supply Division of U. S. Steel Corporation.

Named area engineer was **Thomas M. Harvey,** formerly district engineer at Calgary, Alberta. **Luther T. Tidwell,** whom Harvey succeeds, has been named area manager, machinery sales, with headquarters at Calgary. **Jake B. Burton,** assistant to manager, production equipment sales at "Oilwell's" home offices in Dallas, Texas, has been named area manager, production equipment sales at Edmonton, Alberta.

Abraham Fischer has been named sales and merchandising manager, technical products service department, RCA Service Company, Inc.

Fischer was sales manager, mobile equipment, consumer products service department, prior to assuming his new post.

Donald C. Kilpatrick has been appointed parts sales promotion manager by the Koehring Company.

Kilpatrick has previously held a district representative post covering eight states and several Canadian provinces for Koehring and three of its subsidiary manufacturing firms.

follow the factory's lead . . . get better service from your
Waukesha MOTOR
GAS ENGINES

STITT
NEW TRIPLE IGNITOR
SPARK PLUGS

Waukesha is now factory-installing STITT New Triple Ignitor Spark Plugs in all gas engines . . . STITTS cost a little more—save hundreds of dollars per engine per year because they last longer, cut downtime substantially, increase magneto life, require less service. Also, factory equipment in Clark, Cooper-Bessemer, Worthington, other leading engines.

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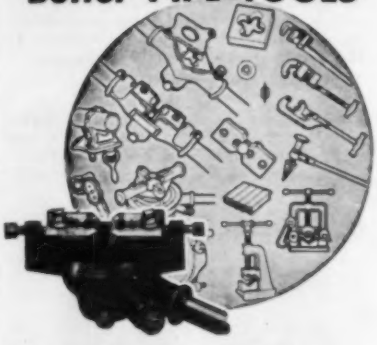
STITT IGNITION CO.
COLUMBUS 1, OHIO
STITT MAKES HEAVY-DUTY, INDUSTRIAL-TYPE PLUGS!

ARMSTRONG BROS.
Better PIPE TOOLS



Reversible Ratchet STOCKS and Adjustable DIES

Exceptionally convenient where space is limited, this stock simplifies pipe threading close to walls, in corners and wherever operating room is restricted. With *adjustable* dies (cut exact, over or under size threads) it is an ideal tool where valves and fittings are being installed or maintained.

"ARMSTRONG BROS." Adjustable Dies are of Special Vanadium Tool Steel, have "backed-off" teeth, correct cutting angle, ample chip clearance and correct throat angle. They start and cut easily, hold their sharpness and "spin" off pipe without jamming or tearing threads.

Write for Catalog

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Trade Personals

William V. Rathbone is now vice president in charge of sales for Delta Tank Manufacturing Company, Inc. He was formerly with Parkersbury Rig & Reel Company, as executive vice president.

W. V. Rathbone

I. M. Baker

I. M. Baker has been named coordinator of sales for the international division of Cameron Iron Works, with headquarters in Houston, Texas. Prior to this recent promotion, Baker was division manager in charge of Latin-American sales.

A. B. Crossno has been appointed division tubular manager of the Northwest division of The National Supply Company, succeeding **C. L. Bainter,** retired. Crossno has been tubular sales representative at the division headquarters in Denver, Colorado.

John C. Madden has been named division tubular manager of the export division of National Supply, with headquarters in New York City. Madden was assistant district manager in New York for the Spang-Chalfant division.

R. F. "Tad" Bartlett has been promoted to branch manager of the Dallas, Texas, branch of the Cooper-Bessemer Corporation. Bartlett has been associated with Cooper-Bessemer since 1934 in the field application of engines and compressors.

Alco Products, Inc., has announced the appointment of three additional sales representatives in the Southwest.

Named are **William L. Wilcox,** Houston, Texas; **W. W. Power,** Lafayette, Louisiana, and **William O. Rogers,** Odessa, Texas.

Allan S. Robertson has been appointed vice president in charge of sales of Fenwal, Inc.

Robertson joins Fenwal from the Union Switch and Signal Division of Westinghouse Air Brake Company, where he was sales manager.

Continental Supply Company announces the following changes in Louisiana store manager personnel:

Henry C. Fox will be the new manager for the Shreveport store while **Ralph A. Broussard** will head the company's new outlet at Morgan City. **Forrest E. Amacker Jr.** will fill Broussard's former position as store manager at Harvey.

James F. Beré has been appointed general manager of Axelson Manufacturing Company, a division of U. S. Industries, Inc.

Beré, for the past year and a half, has been general manager of the Hamilton, Ohio, plant of Clearing Machine Corporation, another division of U. S. Industries, Inc. **Howard W. Carlisle,** formerly assistant sales manager of the Clearing division, will succeed Beré.

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. . . wherever you have stuffing boxes to be repacked, specify Durametallic "Engineered For The Job" products for longer packing life and satisfactory sealing service.
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One of the many uses for Auto-Lite Recorders is the application shown below . . . a natural gas field meter run.
Auto-Lite Model "1000" Temperature Recorder has 6" chart. Various standard ranges from minus 40° F to plus 550° F. Available for wall mounting, portable or portable self contained use. Electric or mechanical chart drive. Choice of 24-hr. or 7-day cycle. Capillary tubing permits remote reading. Priced as low as $49.50. Manufactured to customers' specifications. Send for latest Catalog describing many types of Auto-Lite Recorders and Indicators.
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BOOKS ★

Determination of Shear Stability of Non-Newtonian Liquids, *ASTM Special Technical Publication No. 182, prepared by Neal D. Lawson, published by the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pennsylvania. Pages, 12. Price, 75 cents.*

This publication will be of value to those concerned with development or use of polymer liquids and of mechanical devices in which those liquids are used. It describes several test procedures which are capable of giving comparable results. It reports the data from a cooperative effort to develop a suitable test method for measuring shear stability of Non-Newtonian liquids. The test methods studies included sonic vibrators, sharp-edged orifices, flow through a diesel fuel injector, and a pressure release valve. The two liquids were made by blending polyalkyl methacrylate polymers with a light petroleum base oil.

The material of this report was prepared by N. D. Lawson of E. I. du Pont de Nemours & Co., Inc., for Section B on Viscosity Methods — Non-Newtonian Liquids of Research Division 7 on Flow Properties of ASTM Committee D-2 on Petroleum Products and Lubricants.

Reactions of Carbon With Carbon Dioxide and With Steam, *Research Bulletin 19, By C. G. von Fredersdorff, published by the Institute of Gas Technology, 17 West Thirty-fourth Street, Technology Center, Chicago 16, Illinois. Pages, 76. Price, $7.50.*

Results of 10 years of study of two of the fundamental reactions in the production of manufactured gas have been published in this bulletin. Studies of high-temperature (1700-2500 F) reactions between a solid fuel and oxidizing gases are presented as (1.) the development of mathematical procedures which may have general use in estimating physical and chemical factors associated with carbon gasification, and (2.) application of these procedures to the interpretation of steam and carbon dioxide decomposition rates and gas analyses.

Most of the experimental data were obtained with continuous flow fixed-bed reactors operating at atmospheric and superatmospheric pressures in the Institutes laboratories in Chicago. Results reported by others are analyzed in a literature study and addendum.

CTI Acceptance Test Procedure, CTI Grades of Redwood Lumber, and **Structural Design Data,** *published by the Cooling Tower Institute, 444 Emerson Street, Palo Alto, California. Pages, 2 to 4. Price for single copies, 50 cents for first bulletin, 25 cents for latter two.*

The Cooling Towers Institute has issued three publications of industrial standards for recommendation to purchasers and manufacturers of industrial water-cooling towers. These documents are the result of a five-year program of research conducted by the technical committees of CTI. One year of preliminary study and three years of field investigation were followed by another year of intensive field testing and statistical analysis.

A basic procedure for testing the water-cooling capability of any industrial tower is described in detail in the new CTI bulletin ATP-105 titled "CTI Acceptance Test Procedure." Special grades of redwood lumber recommended by the Cooling Tower Institute for use in industrial towers are described in CTI bulletin STD-101 titled "CTI Grades of Redwood Lumber." Supplementing the specific grades is CTI bulletin STD-102 on "Structural Design Data" in which design stress allowables are described for the CTI Grades of lumber.

ASTM Standards on Plastics (D-20), *published by the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pennsylvania. Pages, 790. Price, $5.75.*

This compilation presents in convenient form ASTM standards and tentative specifications, methods of analysis, methods of physical testing, recommended practices, and definitions of terms pertaining to plastics. It has been substantially revised since the previous edition was published in May 1954. Of the total of 143 specifications and tests, 4 are entirely new and 41 have been either revised, reaffirmed or advanced from tentative status to standard. Two others have been discontinued, one has been replaced, and another has been redesignated as a general method applicable to materials other than plastics.

The standards in this book have been developed by ASTM Committee D-20 on Plastics and will be of special value to plastics engineers and to those concerned with the design and production of plastics and items in which plastics are used. The standards reflect the combined experience of a large number of producers and consumers of plastics as well as many such as university people and others from government bureaus who are interested.

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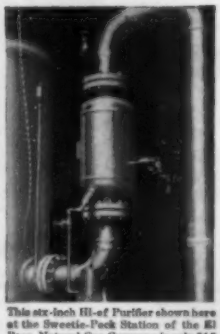

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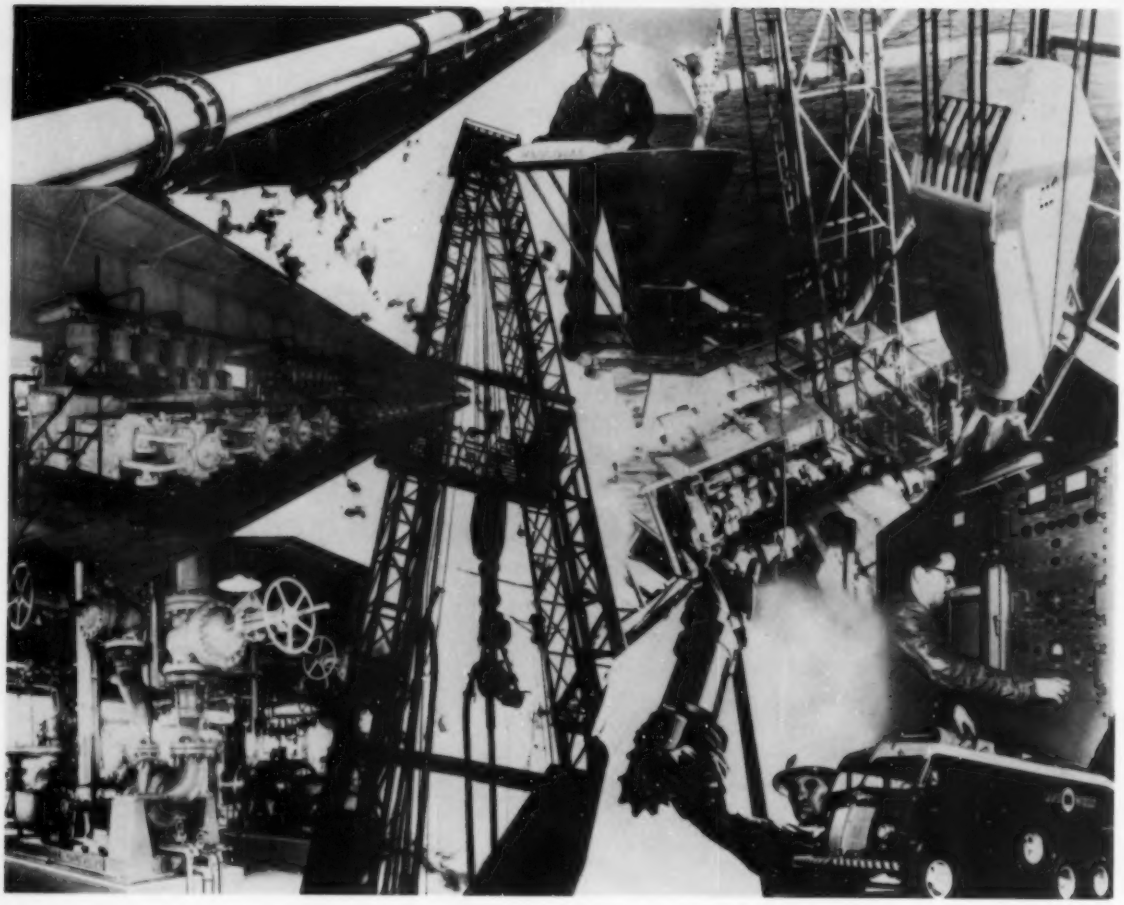

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THE SOLUTION: *Humble's* Thredkote 701,

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When joints coated with *Thredkote 701* are made up tight, a thin film of zinc is deposited on the threads. This film effectively guards against metal-to-metal contact and prevents galling. By using *Thredkote 701* when breaking in new tool joints, and at each regular lubrication, you will prevent thread and shoulder erosion, keeping your tool joints tight and true.

Thredkote 701 is one of a complete line of quality thread compounds. There's one for almost every type of threaded connection.

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New! PATTON oil seal puller

SAVE TIME—MONEY
PULLS OIL SEALS, BEARING RACES BRONZE BUSHINGS

The new PATTON Puller does the job quickly and easily without damage to parts and castings. In addition, oil seals, bearing races and dead-end bronze bushings are removed in a fraction of the time formerly required.

Originally designed for the Armed Forces, the PATTON Puller is now used in machine shops and maintenance and repair shops wherever machinery is repaired. PATTON Pullers save costly man hours and prevent unnecessary damage to component parts. Special sizes can be custom-made for specific requirements. Write for details.

Certain areas are available for qualified distributors.

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PM-8001-3 assy.	7900-573266	13/16" to 29/32"
PM-8001-4 assy.	7900-573266-25	29/32" to 1 5/16"
PM-8001-5 assy.	7900-573266-5	1 5/32" to 1 1/4"
PM-8001-6 assy.	7900-573266-75	1 11/32" to 1 7/16"
PM-8051-3 assy.	7900-573267-5	1 25/32" to 2"

Sizes from 3/8" to 4 1/2" available. Pat. No. 2380068 and Pat. Pend.

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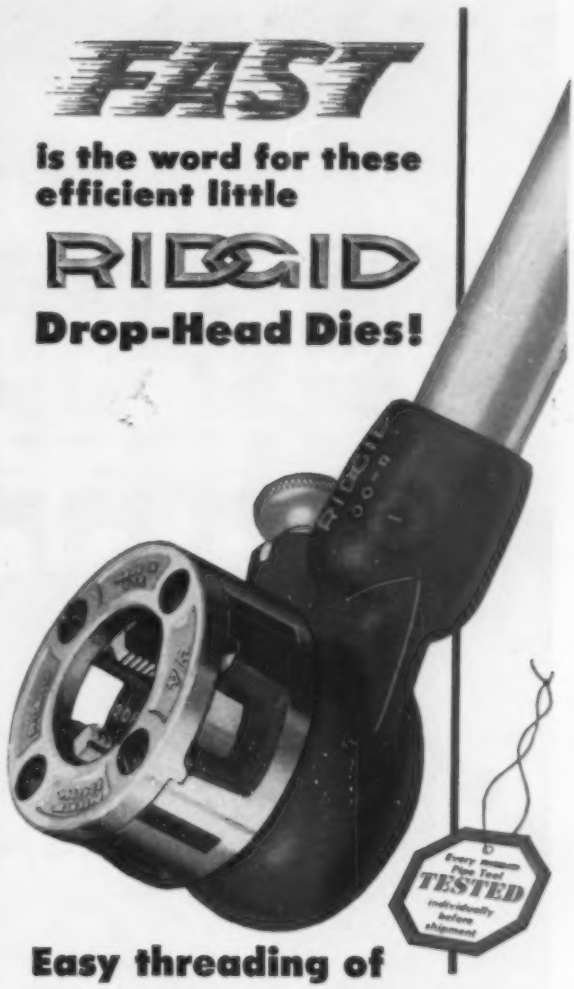

Easy threading of 1/8" to 2" pipe or conduit

Snap size head you want into ratchet drive ring, from either side—it can't fall out. Dies reverse easily for close-to-wall threading. 00R and 0R, 1/8" to 1"; 111R and 11R, 1/8" to 1 1/4"; 12R, 1/8" to 2". Free carrier with sets. Conduit and special dies available. Real work-savers—at your Supply House!

RIDGID *Bolt Threaders, too—No. 00R-B, 1/4" to 1", National coarse and fine thread, efficient drop-head dies.*

"Threaded Pipe—*It's Tight—It's Best—Costs Less*"

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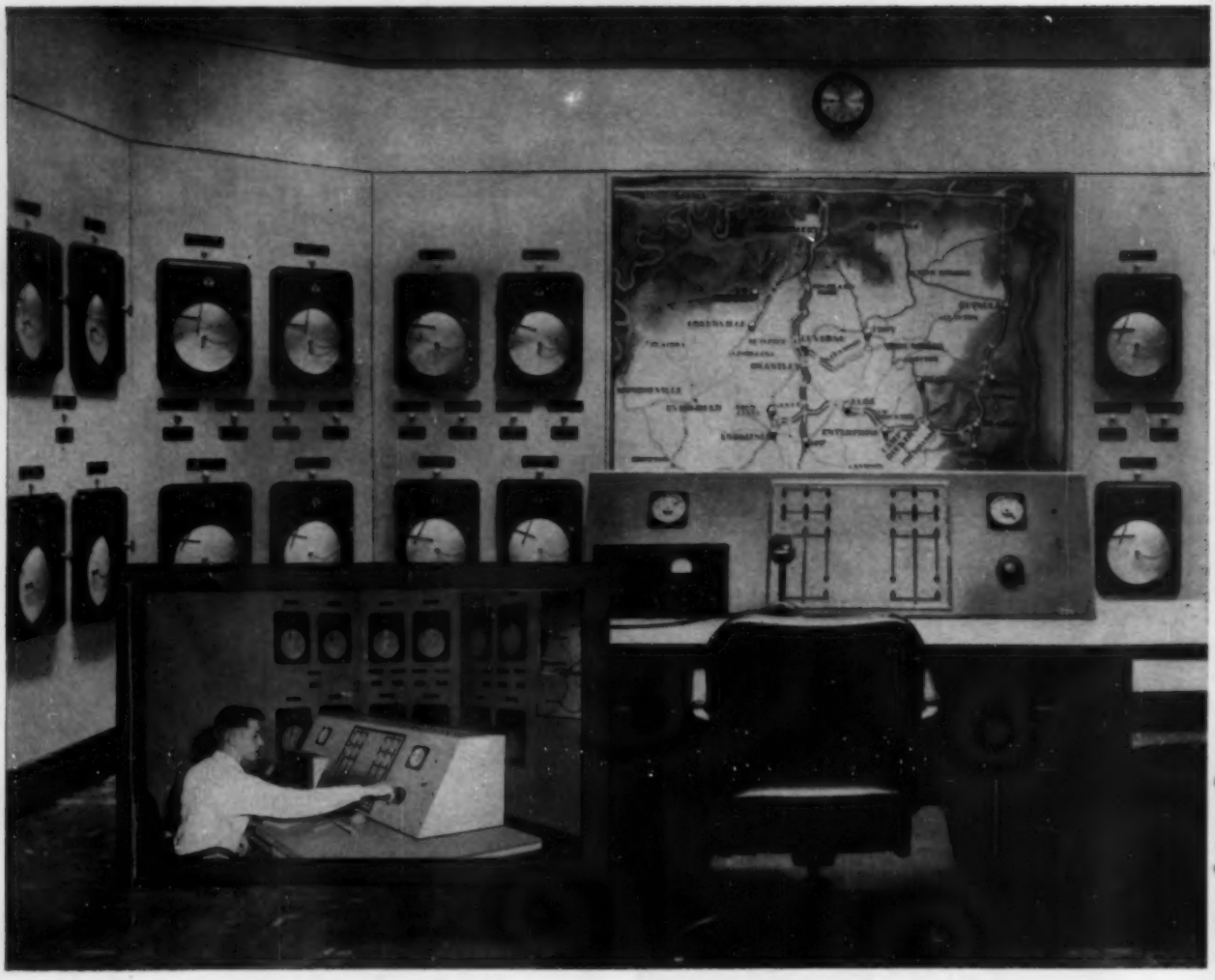
The Ridge Tool Company, Elyria, Ohio, U. S. A.



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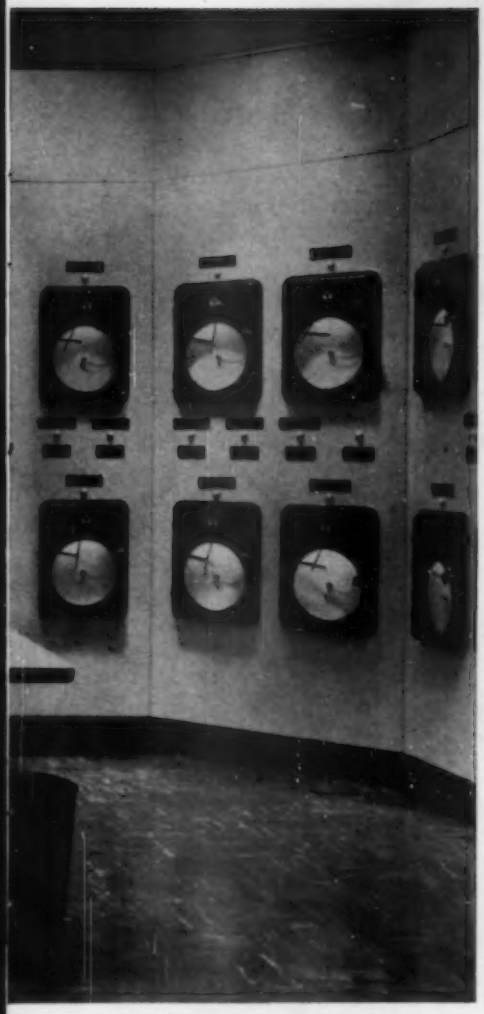
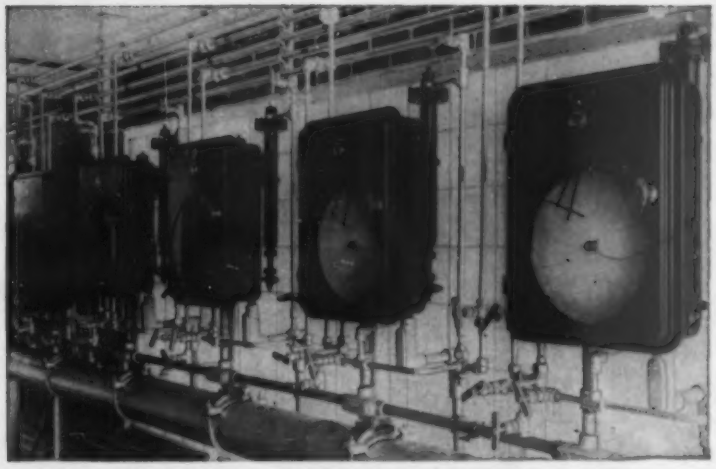
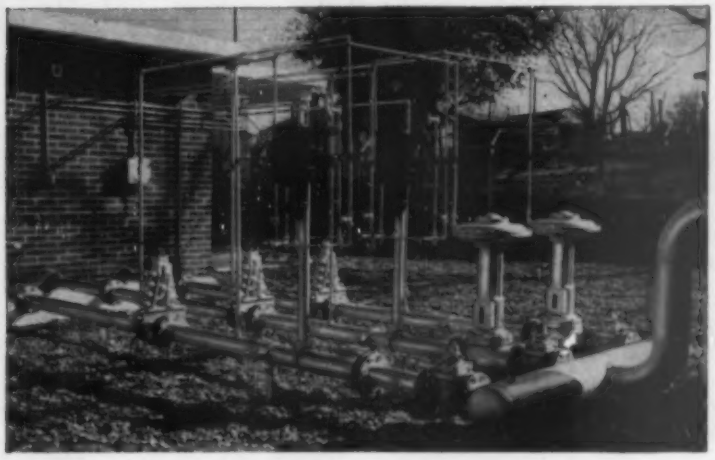


DISPATCHER STATION – By dialing a single circuit, dispatcher obtains total flow in cubic feet and pressure from each of the 14 city gate stations, plus total flow in cubic feet, pressures and differentials of orifice meters and controllers at each intake station to permit complete remote dispatching.



INTAKE STATIONS – All measurement at intake stations, 90 miles and 120 miles from dispatcher's desk, is combined in a totalizing relay which in turn is put on a memory relay to supply total flow since last dialing.



CITY GATE STATIONS – Each station has American automatic measurement, pressure and regulation equipment, totalizing relays and memory relays, enabling dispatcher to obtain flow for any period and obtain pressures. Complete remote control of dual flow differentials, dual first and second stage regulators.

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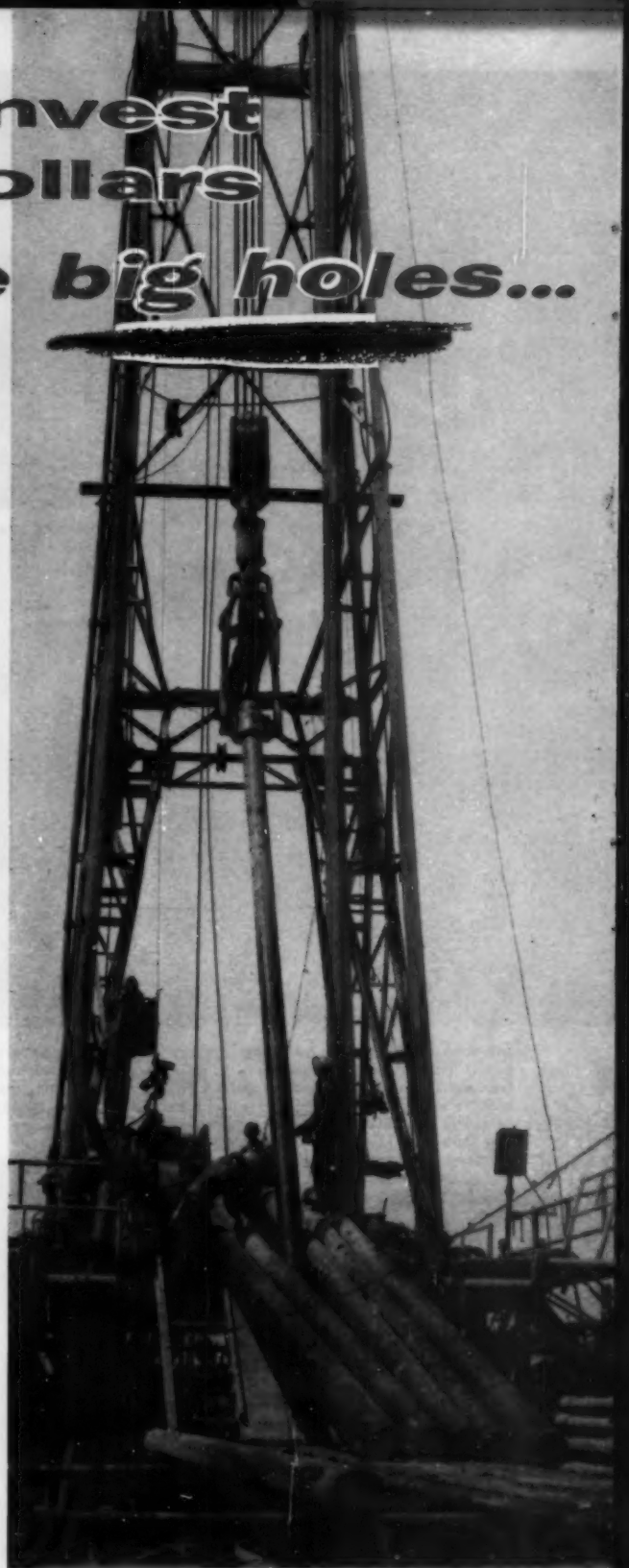

. . . specify National Tube Oil Country Tubular Products. In oil fields throughout the world you'll find USS NATIONAL Seamless Drill Pipe, Casing and Tubing constantly on the job, safeguarding production. Rough and ready to be worked hard, and ready to meet the higher stresses of drilling deeper holes tomorrow.

These NATIONAL Seamless Oil Country Tubular Products are known the world over for their outstanding service record in deep well work. The secret of their strength and dependability may be attributed to two things—quality steel and a unique method of manufacture. Each seamless tube is pierced from a solid billet of steel. And only steel of the very best forging properties and of the highest uniformity can be used, since the piercing operation tends to search out any defects in the metal.

Thus, NATIONAL Seamless Oil Country Tubular Products are built to take the worst that oil well drilling has to offer—*built to give you more service and better service for every dollar you invest.* Remember *that,* the next time you order drill pipe, casing, or tubing.

Some significant developments by National Tube . . .

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Especially well-suited for oil production because of its combination of high yield strength and good ductility.

NATIONAL WARM-WORKED CASING—GRADE N-80

An extremely high-strength casing possessing a uniformity of physical properties which gives it high collapse resistance and greatly increased joint strength. It is hydrostatically tested to 80% of minimum yield strength up to a maximum of 10,000 psi.

NATIONAL DEEP-WELL CASING

A stronger casing than is provided under A.P.I. specifications, to meet constantly increasing depths. Due to the severe service for which it is intended, it is hydrostatically tested to 80% minimum yield strength up to a maximum of 12,000 psi.

NATIONAL (8) BUTTRESS-THREAD CASING

Developed to satisfy the need for a casing joint which will safely and economically support the weight of deep-well casing. The buttress-thread joint is comparable in strength to that of the body of the pipe.

For further information, write to National Tube Division, United States Steel Corporation, 525 William Penn Place, Pittsburgh 30, Pa. Ask for Bulletin No. 15.

NATIONAL TUBE DIVISION, UNITED STATES STEEL CORPORATION, PITTSBURGH, PA.
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

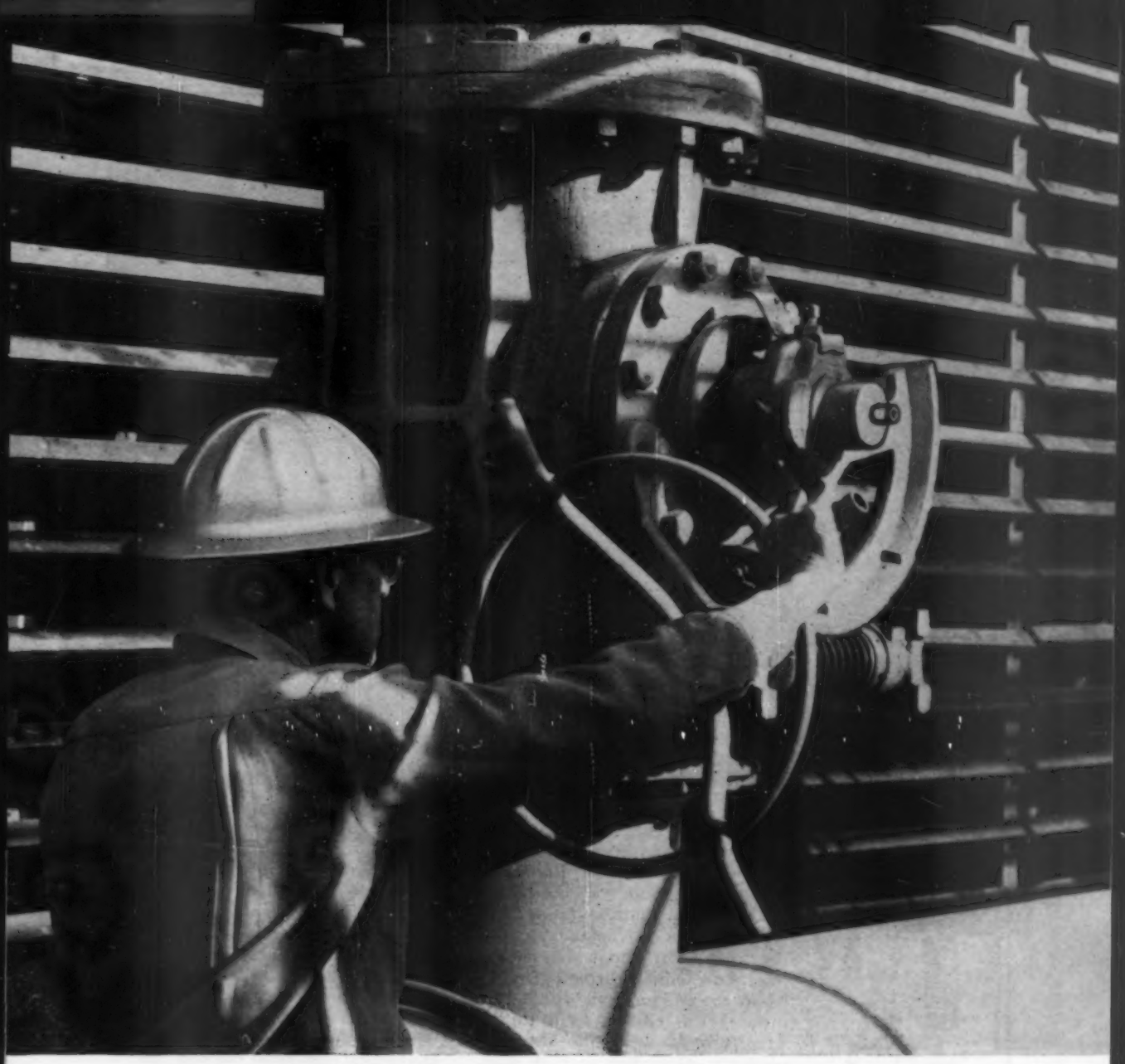
USS

NATIONAL SEAMLESS

DRILL PIPE, CASING AND TUBING

WALLS WITHOUT WELDS

UNITED STATES STEEL



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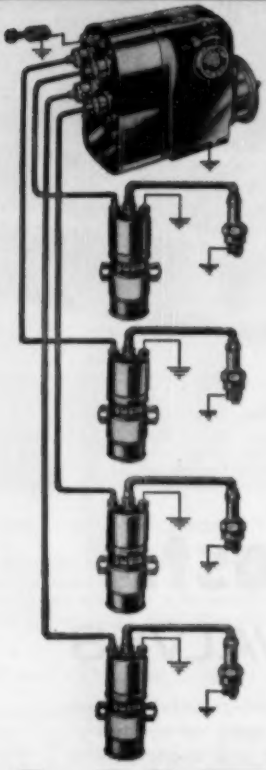
The two most common valve problems that cause excessive down-time costs are seat failure (leakage) and wear. Performance records in thousands of refineries and gasoline plants prove that Rockwell-Nordstrom valves cut down-time costs because they *stay leakproof* and *wear longer in service* than any other valve. In Rockwell-Nordstrom valves, there are no exposed seats to be cut-out or corroded. Leakproof, positive shut-off is assured by pressurized lubricant sealing. Lubricant also eliminates the metal-to-metal friction that causes ordinary valves to wear out so quickly.

The low maintenance cost and dependability of Rockwell-Nordstrom valves is a matter of record, yet they cost no more to buy, often less, than ordinary valves. Available in a complete range of sizes and pressure ratings. Write today for more information: Rockwell Manufacturing Company, Pittsburgh 8, Pa.

Canadian Valve Licensee: Peacock Brothers Ltd.

ROCKWELL-Nordstrom **VALVES**

Lubricant Sealed for Positive Shut-Off
40th YEAR *of lubricated plug valve leadership*



for Large Bore Stationary Gas Engines

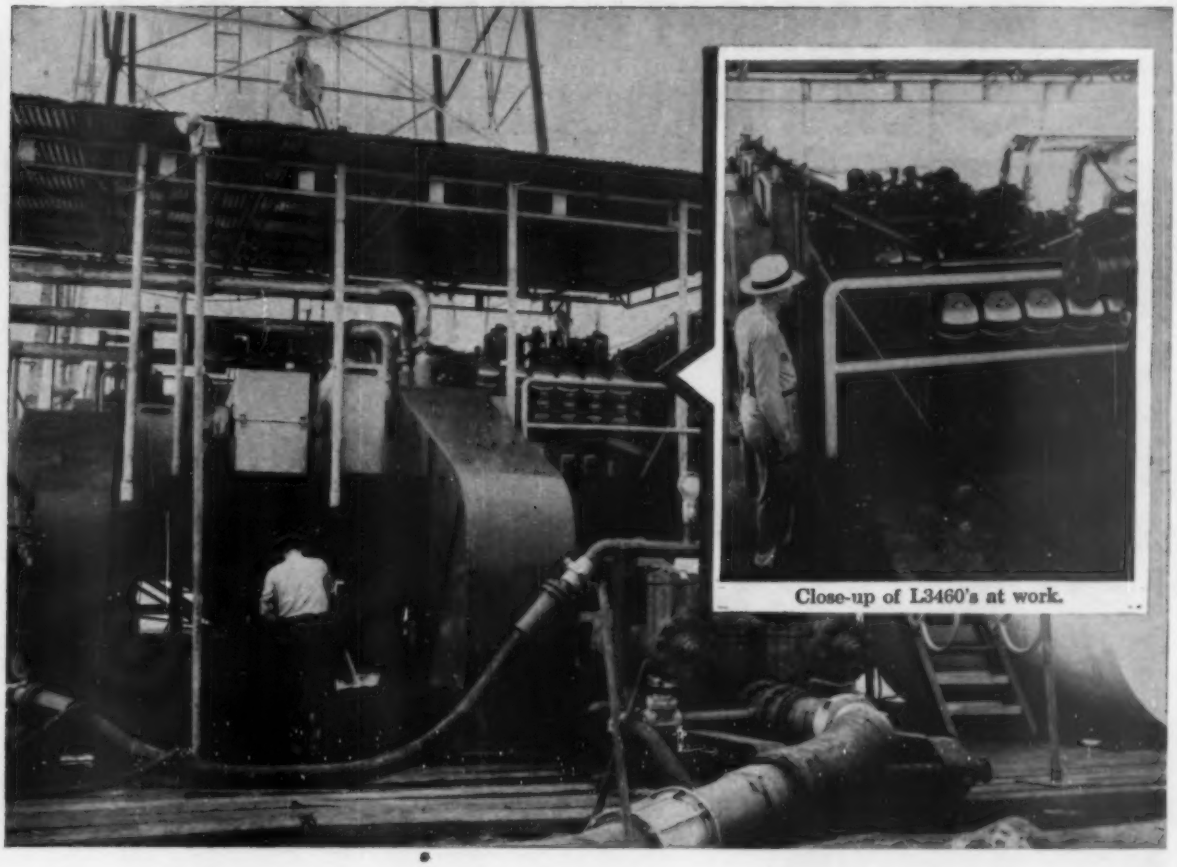
AMERICAN BOSCH

LOW TENSION MAGNETO IGNITION SYSTEM

The System comprises the American Bosch MRB Low Tension, shielded Magneto and individual High Tension Ignition Transformers mounted at each engine cylinder. (See 4 cyl. installation diagram at left). Low tension current, generated in the Magneto, is distributed through low tension leads to the Transformers. Here, the electrical energy is stepped-up to high voltage and conducted to the spark plugs by short cables—shielded if desired. The rugged, heavy-duty, high tension Transformers (as illustrated above) are available with or without shielding for use in the American Bosch System or other low tension systems employing magneto or battery ignition.

Energy losses and corona effects which occur with long high tension cables are eliminated. The possibility of fire and explosion hazard is minimized where engines operate in combustible vapors . . . radio and TV interference may be greatly reduced by complete shielding. These important advantages, combined with the outstanding electrical and mechanical features of the American Bosch Low Tension Magneto, offer maximum spark efficiency for large bore, stationary engines operating under severest conditions. For peak engine performance and safer, continuous service, get the facts from American Bosch, Springfield 7, Mass. A Division of American Bosch Arma Corporation.

AMERICAN BOSCH



Close-up of L3460's at work.

Here's the Way to Power a Rig... for Deep Holes!

... use LeRoi L3460 or L4000 V-12 drilling engines to get the outstanding acceleration and lugging power you need for faster round trips

If you have an engine that can stand the gaff on deep holes — you have an engine that can help you bottom any hole at lower cost.

The L3460 and L4000 can do just that. It's been proven time and time again.

Let's look at the L3460. It develops 600 hp maximum. On one rig two of these engines hoisted 5-inch pipe from 8300 feet in just two hours — and this was a wet trip. That's proof of both acceleration and lugging power.

The L4000 is the L3460's twin except for displacement. It produces 655 maximum hp. Both engines are only 164 inches long so that they have the compactness that helps you keep to overall width and weight limitations. And they're built to stand oil-field handling.

Not only do you get more horsepower per dollar from these V-12's, but you also get these important features: Short-stroke design that gives you greater horsepower and speed, without compromising engine life. Wide speed range up to 1350 rpm. Operation on oilfield fuels —natural gas or butane. Conservative rating. Lightweight pistons, hydraulic tappets, short-radius rotating parts, and sensitive controls to provide hair-trigger response to load demands.

Yes, you can drill them deep and drill them fast with L3460's or L4000's. Let your supply house or Le Roi distributor show you why. If you want descriptive literature, just write us for it.

P-136

LE ROI *Division of Westinghouse Air Brake Co.*

Milwaukee 1 Wisconsin

PORTABLE AIR COMPRESSORS · TRACTAIR · STATIONARY AIR COMPRESSORS · AIR TOOLS · ENGINES

A NEW CONCEPT IN FLEXIBLE POWER FOR RIMROCK TIDELANDS

RIGELECTRIC* by STEWART & STEVENSON

Out in the Gulf, they're playing for keeps. And that's why Rimrock Tidelands, Inc. selected RIGELECTRIC. RIGELECTRIC is the newest and most flexible concept in diesel or gas engine electric drilling rig power, and besides that, RIGELECTRIC is backed by Stewart & Stevenson Service.

RIGELECTRIC, designed and engineered by Stewart & Stevenson, offers the maximum in dependability and reliability. The skid-mounted unit, which consists of two main generators and four General Motors 6-110 Diesel Engines, can operate in emergencies with one or more engines out of service. Other features included choice of fuel selection, simple controls and low cost maintenance and parts. And despite the flexibility and extra insurance provided by RIGELECTRIC, any mechanical equipment eventually must be repaired and serviced. And oil operators have learned from experience that the full and undivided parts and service responsibility of Stewart & Stevenson stands unconditionally behind every Stewart & Stevenson installation, day or night on land or water.

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*"RIGELECTRIC" REGISTERED TRADE MARK FOR STEWART & STEVENSON DC DRILLING RIG POWER

STEWART & STEVENSON

THE NATION'S LARGEST DISTRIBUTORS OF GM DIESEL ENGINES

BEAIRD-INGERSOLL-RAND

Packaged Compressor Plant

Lowest Cost Per Horsepower Installed

SOUTHERN UNION GAS COMPANY'S REMOTE-CONTROLLED COMPRESSOR STATION—equipped with a Beaird-Ingersoll-Rand 550 h.p. 10 SVG compressor. Young radiator with lubricating oil cooler and gas coolers, and all necessary controls for unattended operation. Other sizes 110 to 660 h.p.

Southern Union Gas Company's Dogie Compressor station in El Largo Canyon, New Mexico, is more than 20 miles from the nearest paved highway and many miles farther from the nearest town. To boost gas from this lonely site Southern Union has installed a Beaird-Ingersoll-Rand 550 hp. 10 SVG packaged compressor.

Part of a 500-well gathering system, the Dogie Station compressor uses one stage of compression to pick up gas from 20 wells in nearby Ballard Field and boost it from 250 psig. to 500 psig. for delivery to the main line.

Normally inspected once a day, the station has been designed to overcome potential isolation caused by roads made impassable by deep snow, rain, swollen rivers and washes during severe San Juan winters. This problem of isolation has been solved by equipping the compressor with automatic controls and shut down devices that stand by day and night to protect the station and plant should any unusual operating condition occur. Now on a 40-hour weekly maintenance schedule, the station is capable of long periods of completely unattended operation.

Let us show you how a Beaird-Ingersoll-Rand packaged compressor plant can be designed to meet your special operating requirements.

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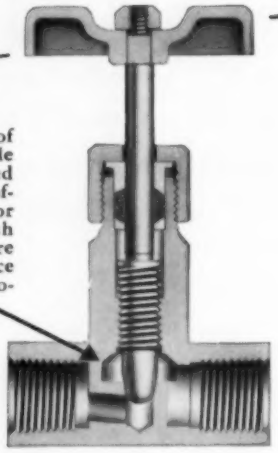
MAXIMUM WORKING PRESSURE
10,000 PSI
for water, oil or gas

- Body and stem guide extra heavy bar stock fused into one piece.
- Valve stem 416 stainless steel.
- Packing special one-piece "Marpak" moulded ring.
- Bodies marked in accordance with MSS regulations.

ONE PIECE

The stem guides of conventional needle valves are screwed into bodies—this often causes leakage or blow-outs. Marsh Needle Valves are fused into one-piece by exclusive "Conoweld" process.



The Ultimate in Needle Valves

Here is one of the crowning achievements of Marsh research, design, and manufacturing skill. It is the first needle throttling and shutoff valve to combine *all* of the qualities called for today in this highly critical and ever broadening field.

It is a valve that has strength and safety to spare . . . rated for pressures up to 10,000 psi—equally efficient in the lower ranges. A product of Marsh instrument-making and valve manufacturing experience, it combines instrument-like precision with the ruggedness that distinguishes all Marsh valve specialties.

The illustrations tell the story of new thinking; new standards. Body and stem-guide are machined from extra-heavy carbon steel bar stock. Still greater strength and rigidity are achieved by fusing the stem-guide into the body. The complete fusion of guide and body is accomplished by the exclusive Marsh "Conoweld" process.

There are two big advantages to this one-piece construction: (1) It eliminates the danger of unscrewing the valve from the body when opening—a frequent cause of leakage, even dangerous blow-outs (2) It permits perfect line-up of threads and seat. As a result, Marsh valves are easier to operate even at high pressures.

The precision-machined stem is 416 stainless steel. Stem threads are fine pitch for extra strength and fine, controlled regulation. Notable advancements are special "Marpak" one-piece, non-binding longer-lasting packing; deep thread chambers, keeping inlet and outlet piping away from ports and contributing excellent flow characteristics. Entire packing nut and packing gland are electro-zinc plated, preventing corrosion and giving the valve a handsome, plated exterior. The rugged malleable handle is finished in heavy baked enamel.

The new needle valve line includes globe and angle patterns with double female connections in sizes ⅛", ¼", ⅜", ½", ¾" and 1". Also globe and angle valves with male inlet and female outlet in sizes ¼" and ½". *Complete stock carried at our Skokie, Illinois factory and also at our branch plant in Houston, Texas.*

Write today for catalog giving complete details.

MARSH INSTRUMENT CO. *Sales Affiliate of Jas. P. Marsh Corporation*
Dept. M, Skokie, Ill. • **Marsh Instrument & Valve Co. (Canada) Ltd., 8407 103rd St., Edmonton, Alberta** • **Houston Branch Plant: 1121 Rothwell St., Sect. 15, Houston, Texas**

MARSH

"THE STANDARD OF ACCURACY"

JOHN WIGGINS' ANSWERS TO 8 QUESTIONS CAN HELP YOU SELECT A BETTER FLOATING ROOF SEAL

Are all floating roof seals the same? What about safety? Conservation? We asked John Wiggins, inventor of the floating roof and noted conservation authority, to answer questions most commonly asked about the new Wiggins Safety Seal.

1—**Q.** In the new Wiggins Safety Seal does any of the mechanism contact the liquid?

A. No. All metal working parts are out of the liquid away from corrosive vapors.

2—**Q.** Does the new "Weather Hood" provide longer fabric life?

A. Yes—the fabric is protected from the sun and other elements—lower temperature under the hood provides added conservation.

3—**Q.** In old style seals, rust and scale accumulate and shorten seal life. Does this happen with this seal?

A. The "Weather Hood" prevents rust and scale from depositing in the "seal loop"—thereby increasing seal life.

4—**Q.** Does the Wiggins Safety Seal prevent rim fires?

A. Yes—design of the seal virtually eliminates critical vapor spaces where air and vapor collect to form explosive mixtures. When exploded through controlled tests, the fabric was able to expand enough to contain the explosion without tearing.

5—**Q.** Is this seal safe for the storage of low vapor-pressure, low flash-point liquids such as jet fuels?

A. Yes, the design of the Wiggins Safety Seal reduces the danger area to a minimum so that it can be used in the storage of jet fuels with complete confidence.

6—**Q.** How does the Wiggins Safety Seal guarantee maximum protection against evaporation loss?

A. Air-vapor volume of the Safety Seal is less than 10% of the present volume for floating roof seals. This would eliminate most losses. In addition, the air-vapor space is shielded by a "Weather Hood". This area—the area that breathes—reduces losses to a minimum.

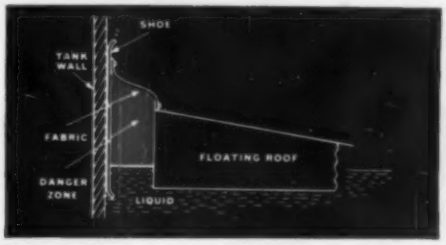
7—**Q.** Will the Wiggins Safety Seal save me money?

A. Yes—by eliminating losses due to thermal breathing, preventing rim fires, use of new longer-lived fabric, protecting the mechanism from liquid and corrosive vapors and permitting much longer periods of "in-service" operation.

8—**Q.** Why have you put so much emphasis on the seal?

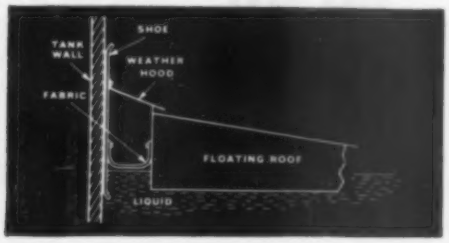
A. A floating roof is only as safe as its seal. With the new Wiggins Safety Seal, Wiggins floating roofs are in a class by themselves. Since General American makes all types of floating roofs, you can have the Wiggins Safety Seal on the roof that best meets your needs—whether it be the Wiggins Hidek*-Lodek* or Doubledek*.

*Patented



OLD

With the old type seal, the fabric is exposed to the sun's rays and explosive vapor collects in the large space between the liquid and the fabric; the mechanism is submerged in the liquid and exposed to corrosive vapors.



NEW

With the new Wiggins Safety Seal, vapor space under the circumferential fabric is reduced to a minimum. Ends spark fire hazards. Fabric is protected from the sun. Mechanism is out of liquid and corrosive vapor space.

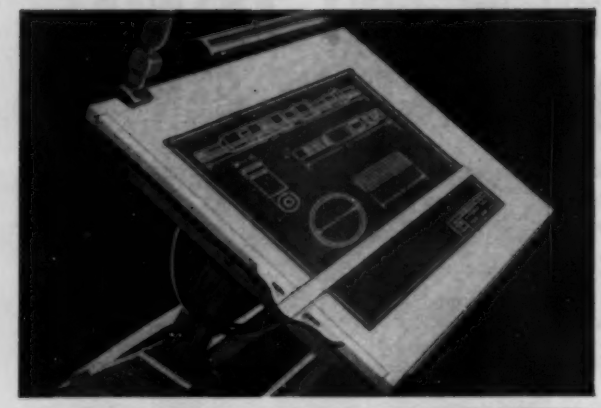
To see why Wiggins Floating Roofs pay for themselves, write or call your General American sales engineer.

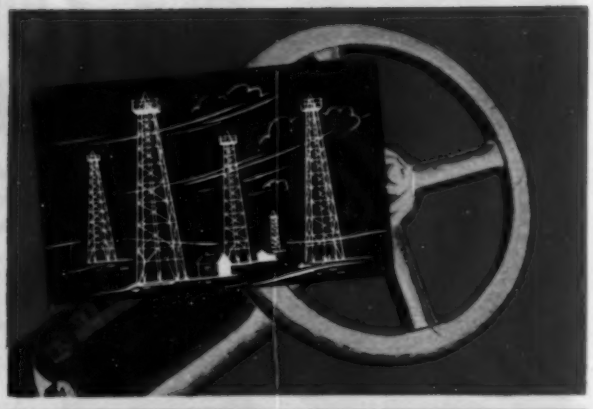
PLATE AND WELDING DIVISION

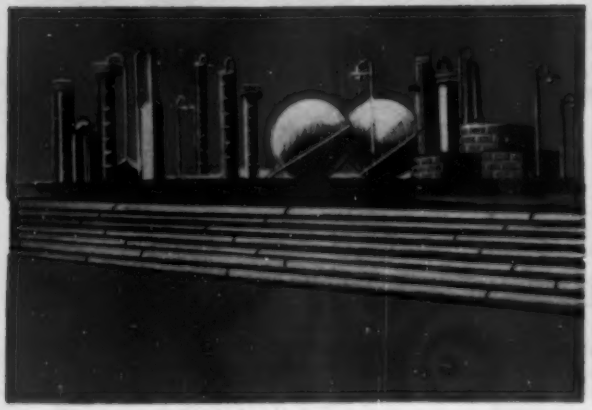
GENERAL AMERICAN TRANSPORTATION CORPORATION

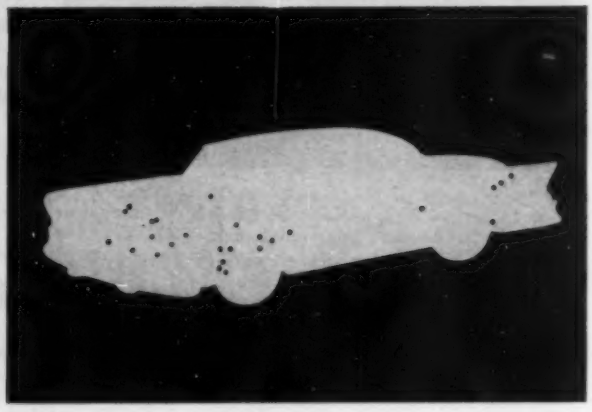
135 South La Salle Street, Chicago 90, Illinois

Naugatuck Paracrils









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- High abrasion resistance
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If your rubber or rubber-like products require high oil resistance it will profit you to investigate Naugatuck's PARACRILS. Why not write to us on your company letterhead TODAY?

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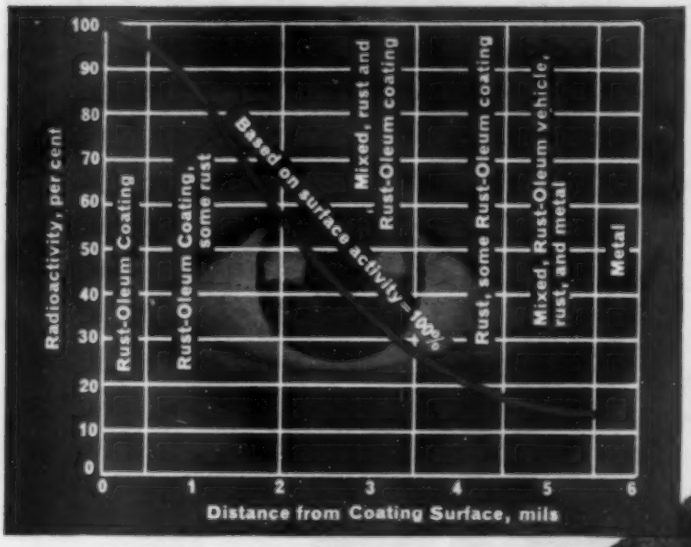
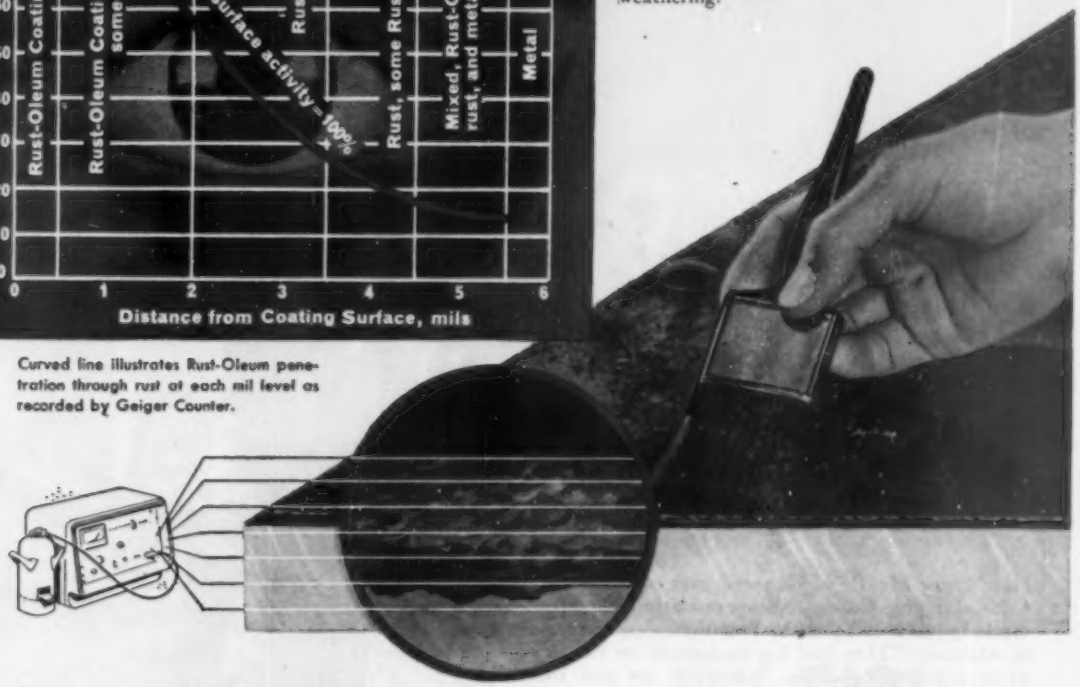
See Rust-Oleum *penetrate rust* to bare metal through the "Eyes" of Radioactivity!



Curved line illustrates Rust-Oleum penetration through rust at each mil level as recorded by Geiger Counter.

Rust-Oleum dries to a firm, decorative coating that resists salt water, sun, fumes, heat, humidity, and weathering.



Geiger Counter traces Rust-Oleum penetration to bare metal! In nearly three years of radioactive research, Rust-Oleum's *specially-processed* fish oil vehicle was radio-activated and formulated into Rust-Oleum 769 Damp-Proof Red Primer – then applied to rusted test panels. Rust-Oleum's specially-processed fish oil vehicle was then traced through the rust to bare metal by Geiger Counter.

This penetration means rust-stopping power, because the fish oil vehicle works its way into the tiny pits in the metal where it drives out air and moisture that cause rust. Important savings are yours, because Rust-Oleum can be applied directly over sound rusted surfaces – usually eliminating costly surface preparations. Attach coupon to your business letterhead for your copy of the thirty-page report entitled, "The Development of a Method To Determine The Degree of Penetration of a Rust-Oleum Fish-Oil-Based Coating Into Rust On Steel Specimens," prepared by Battelle Memorial Institute technologists. Prompt delivery of Rust-Oleum is assured from your nearby industrial distributor.

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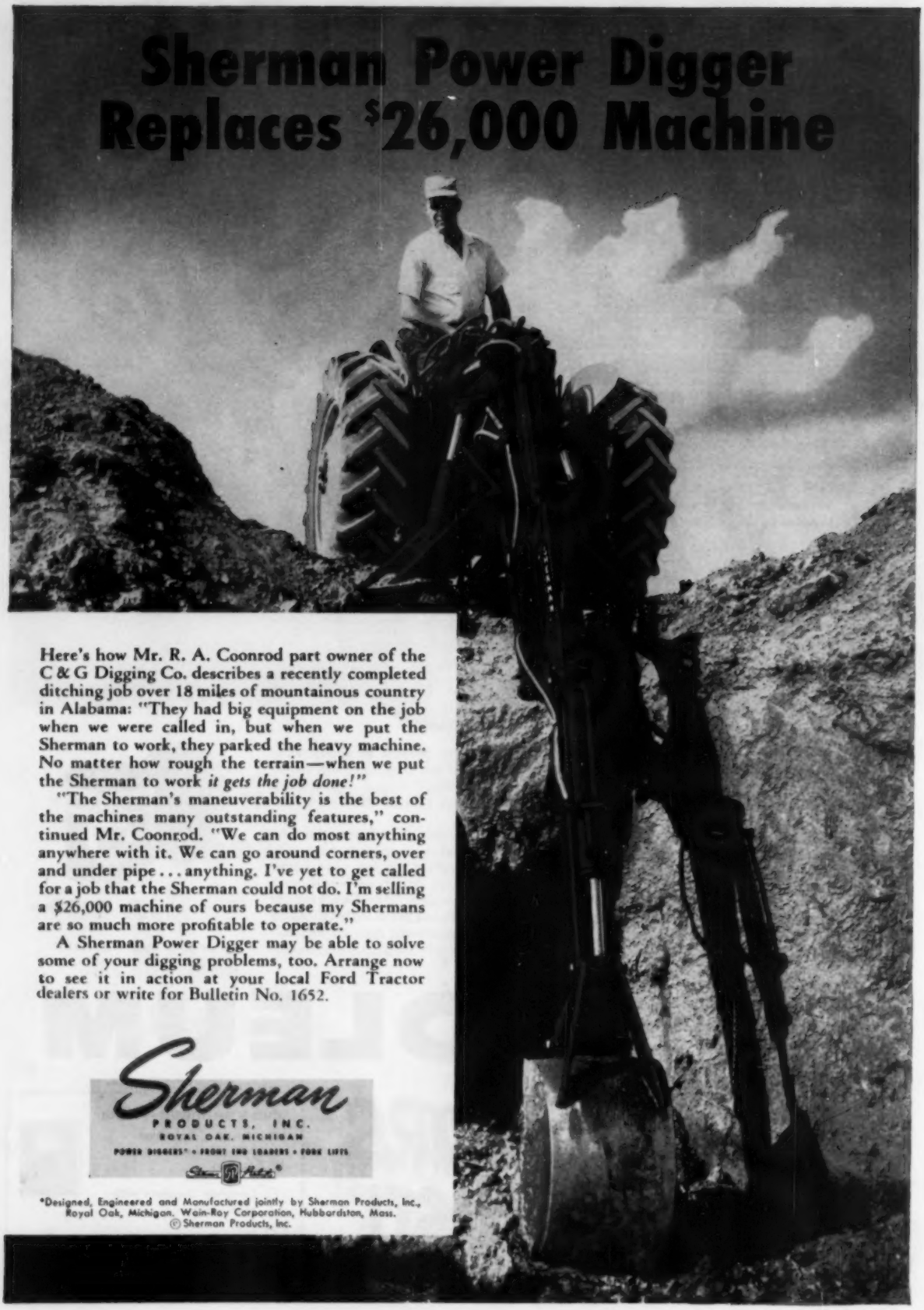
Sherman Power Digger Replaces $26,000 Machine



Here's how Mr. R. A. Coonrod part owner of the C & G Digging Co. describes a recently completed ditching job over 18 miles of mountainous country in Alabama: "They had big equipment on the job when we were called in, but when we put the Sherman to work, they parked the heavy machine. No matter how rough the terrain—when we put the Sherman to work *it gets the job done!*"

"The Sherman's maneuverability is the best of the machines many outstanding features," continued Mr. Coonrod. "We can do most anything anywhere with it. We can go around corners, over and under pipe . . . anything. I've yet to get called for a job that the Sherman could not do. I'm selling a $26,000 machine of ours because my Shermans are so much more profitable to operate."

A Sherman Power Digger may be able to solve some of your digging problems, too. Arrange now to see it in action at your local Ford Tractor dealers or write for Bulletin No. 1652.

Sherman
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ROYAL OAK, MICHIGAN
POWER DIGGERS* • FRONT END LOADERS • FORK LIFTS
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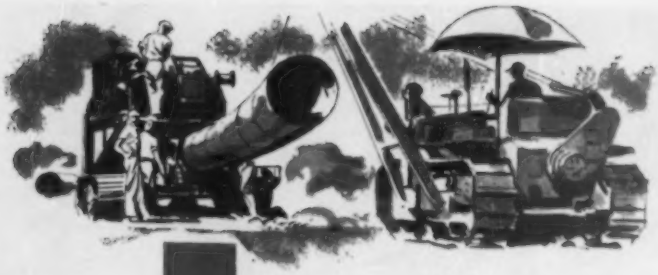

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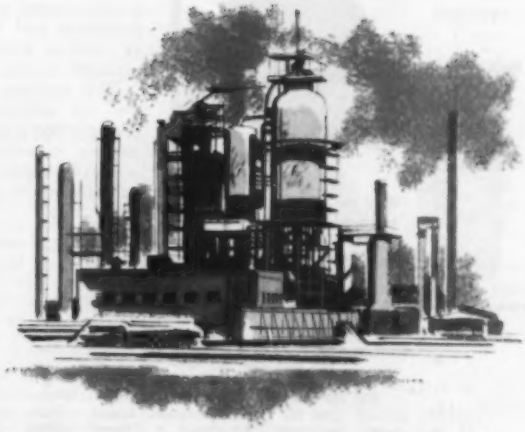

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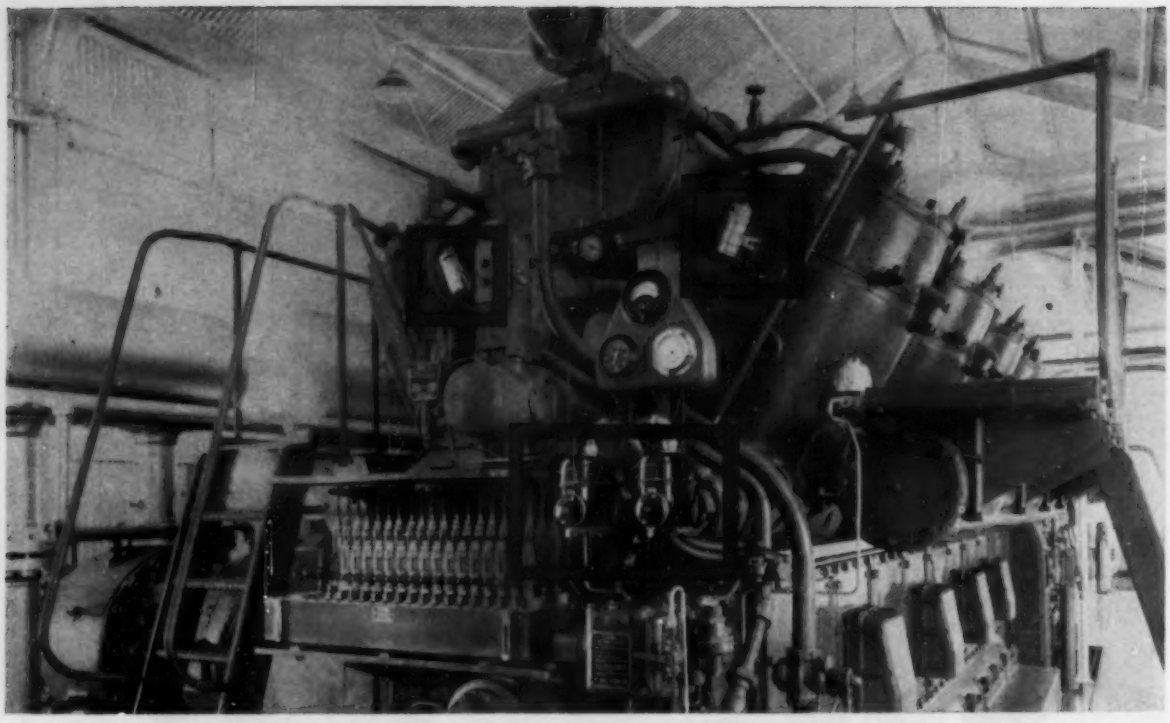

On the Job in the Oil Fields

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LAR Magneto
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Continuous reliable engine performance is a must in the great oil fields of the Southwest. Pictured above is a Cooper-Bessemer Model GMVA engine equipped with Bendix* LAR type magnetos and HI-V transformer coils at work in a natural gas transmission pipeline station.

This modern LAR Bendix magneto and its companion high-output coil give the kind of reliable ignition that assures constant efficiency at lower operating costs. Reserve power insures smooth running engines, even under the most adverse operating conditions where marginal systems fall down.

The selection by Cooper-Bessemer of this performance proven, matched ignition system is further proof that Bendix—The Most Trusted Name in Magnetos—is more and more becoming the choice of leading engine builders.

Kits are now available to convert Bendix LA magnetos to the modern LAR type at surprisingly low cost. Complete details are available either from the factory or authorized distributors.

*TRADE MARK

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Experienced all phases construction engineering concerning marketing petroleum products, i.e., appropriations, terminal layout and maintenance. M.E. or C.E. degree desirable but not essential. Working knowledge French essential.

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Mature business man with solid background in management, sales, purchasing, credits, and personnel in petroleum equipment supply field — also Washington, D.C. experience in handling matters involving federal agencies — interested in connection with company where such qualifications needed either on advisory or consulting basis. Now employed, with extensive acquaintances. Well informed concerning industry conditions, including financial, in major and independent operations, drilling, manufacturing and supply fields. Write Box 181 c/o **The Petroleum Engineer, P. O. Box 1589, Dallas, Texas.**

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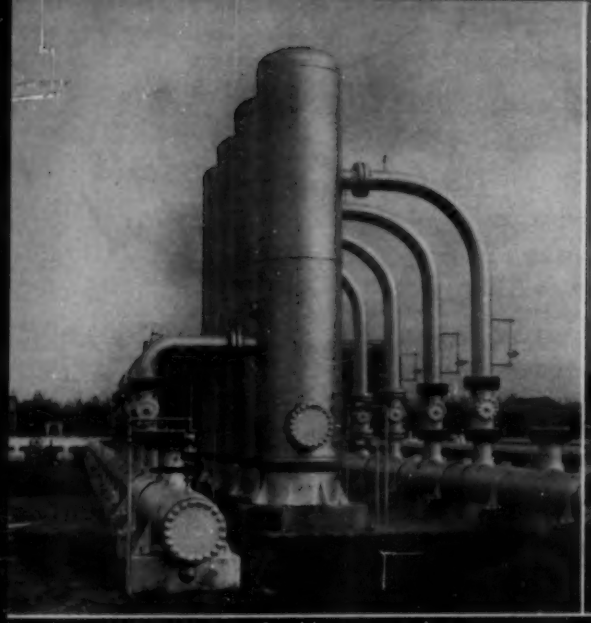
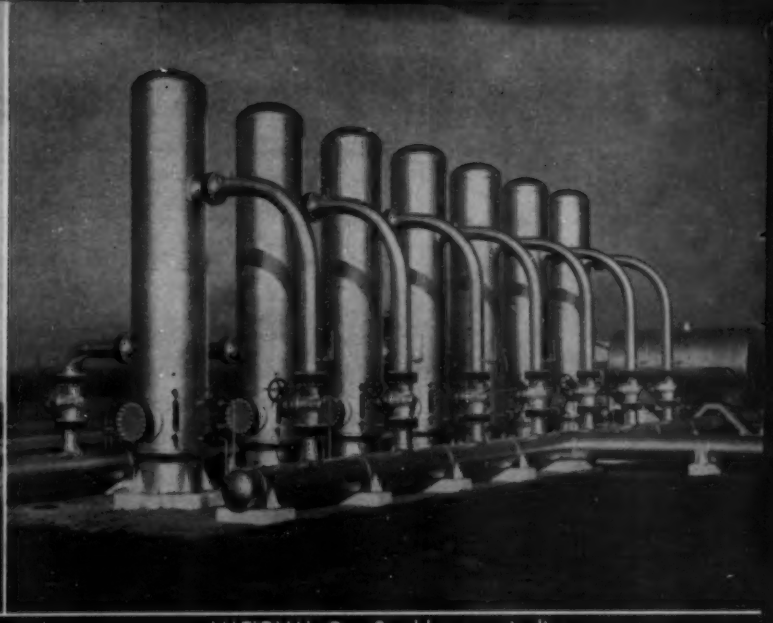
HOTEL CLOVIS	Clovis
SOUTH CAROLINA	
HOTEL WADE HAMPTON	Columbia
TEXAS	
HOTEL STEPHEN F. AUSTIN	Austin
HOTEL BROWNWOOD	Brownwood
HOTEL BAKER	Dallas
HOTEL TRAVIS	Dallas
HOTEL CORTEZ	El Paso
HOTEL BUCCANEER	Galveston
HOTEL GALVEZ	Galveston
HOTEL JEAN LAFITTE	Galveston
CORONADO COURTS	Galveston
HOTEL PLAZA	Laredo
HOTEL LUBBOCK	Lubbock
HOTEL FALLS	Marlin
HOTEL CACTUS	San Angelo
HOTEL MENGER	San Antonio
ANGELES COURTS	San Antonio
VIRGINIA	
HOTEL MOUNTAIN LAKE	Mountain Lake
HOTEL MONTICELLO	Norfolk

TELEPHONE
NEW YORK—Murray Hill 6-6990
CHICAGO—Harbert 4-5100
WASHINGTON—Executive 3-5401
MEXICO CITY—10-4800
GALVESTON—5-8536
CLEVELAND—Prospect 1-7077

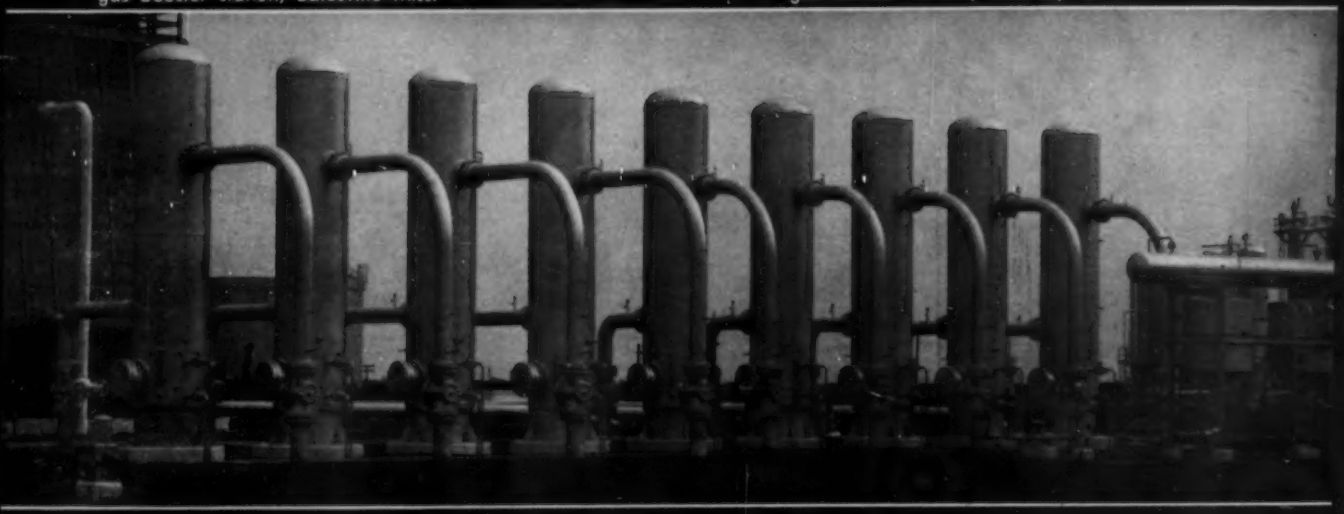
AFFILIATED NATIONAL HOTELS



NATIONAL Gas Scrubbers, main line gas booster station, Batesville Miss.



NATIONAL Gas Scrubbers, main line gas booster station, Monroe, La.



NATIONAL Gas Scrubbers, main line gas booster station, Banquitte, Texas

NATIONAL WET-TYPE SCRUBBERS

54" O.D. x 20' — 750 PSI MAX. WP.
90 MM CU. FT./DAY. 12" INLETS AND OUTLETS

The service required of Wet-Type Scrubbersl Pipe line dust and other foreign materials are removed ahead of compressors at each pressure boosting station. This is done best by passing the gas through a special oil bath in a National Wet-Type Scrubber, then removing the liquid particles from the gas stream when passing through the National Gas Scrubbing element in the top part of the Scrubber.

National Vertical and Horizontal Gas Scrubbers are available in a wide range of sizes, working pressures and capacities to fit the needs of gas producers and carriers.

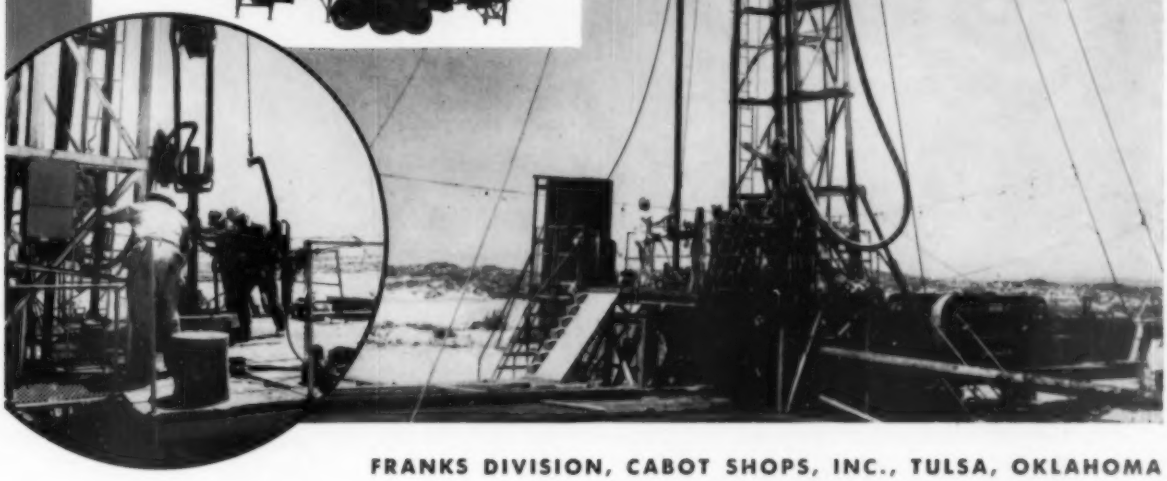
It's a National®

NATIONAL TANK COMPANY

TULSA, OKLAHOMA

FRANKS RIG-UP and MOVING SPEED = DRILLING ECONOMY

A Franks COMET takes less capital to rig out. This, plus exceptional moving speed, gives you high profit per hole drilled. Compare your cost records with those of a contractor drilling with a COMET now.



FRANKS DIVISION, CABOT SHOPS, INC., TULSA, OKLAHOMA

Trying to keep your drilling crews busy making hole? Faster tear-down, moving and rig-up with a Franks COMET drilling rig is the answer. Derrick stays strung up during moves, and basic components of Franks COMET move in three loads.

On one trailer: drawworks, engine pump drive, covered drive lines and chains, full length walkways and derrick. On second trailer: complete substructure, pipe rack, in-place rotary table and accessories. Independent mud pump is on third trailer. Franks portable design saves money and time in moving without sacrificing drilling speed, or operation ease and safety around the table.

FRANKS
DIVISION CABOT SHOPS INC
WELL SERVICING AND DRILLING UNITS
TULSA, OKLAHOMA

"ON THE SPOT" FIELD SERVICE

CABOT
SHOPS, INC.

Drilling in the Elk Basin, Park County, Wyoming, Bob Mangan, Toolpusher on Anschutz Drilling Company's Rig #7, proved to himself the superior performance of SECURITY rock bits by testing them against other leading bits.

TYPE FOR TYPE—SECURITY BITS PROVED BEST!

"Security Rock Bits have proved themselves better than any other bits I've used," says Bob Mangan, Toolpusher on Anschutz Drilling Company's Rig #7. "We recently compared *Security* with competitive bits on several Rocky Mountain locations. Type for type and size for size, *Security* dug faster, averaged more hole per bit, and came out looking better."

In the highly competitive oil well drilling industry, a little extra footage per bit — plus slightly greater penetration rate — can mean the difference between profit and loss. That's why progressive toolpushers like Bob Mangan test and compare leading brands of bits. They know you can't afford to be guided solely by tradition in the choice of rock bits. After all, the proof of rock bit performance is in the digging — not how long it has been on the market.

If your business is drilling oil wells — and you aren't already using *Security* bits — you owe it to your balance sheet to try *Security* on your next location. Give *Security* a fair trial on one hole, and you, too, will be convinced that *nothing outdigs Security*. Write for catalog.

Security **ENGINEERING DIVISION**

Dallas, Texas • Whittier, California

Export Office: Chanin Bldg., New York, N. Y.

ROCK BITS • REAMERS • CASING SCRAPERS • RUBBER STABILIZERS • HOLE OPENERS

Of Things To Come . . . In Oil

OIL RECOVERY IN U.S. MAY BE DOUBLED if new idea works out in field practice. Clearly presented for first time in this issue, miscible displacement theory utilizes present gas injection methods. Secret lies in control of composition of injected gases. Recoveries above 90 per cent not out of reason. Brightest news to come along since water flooding.

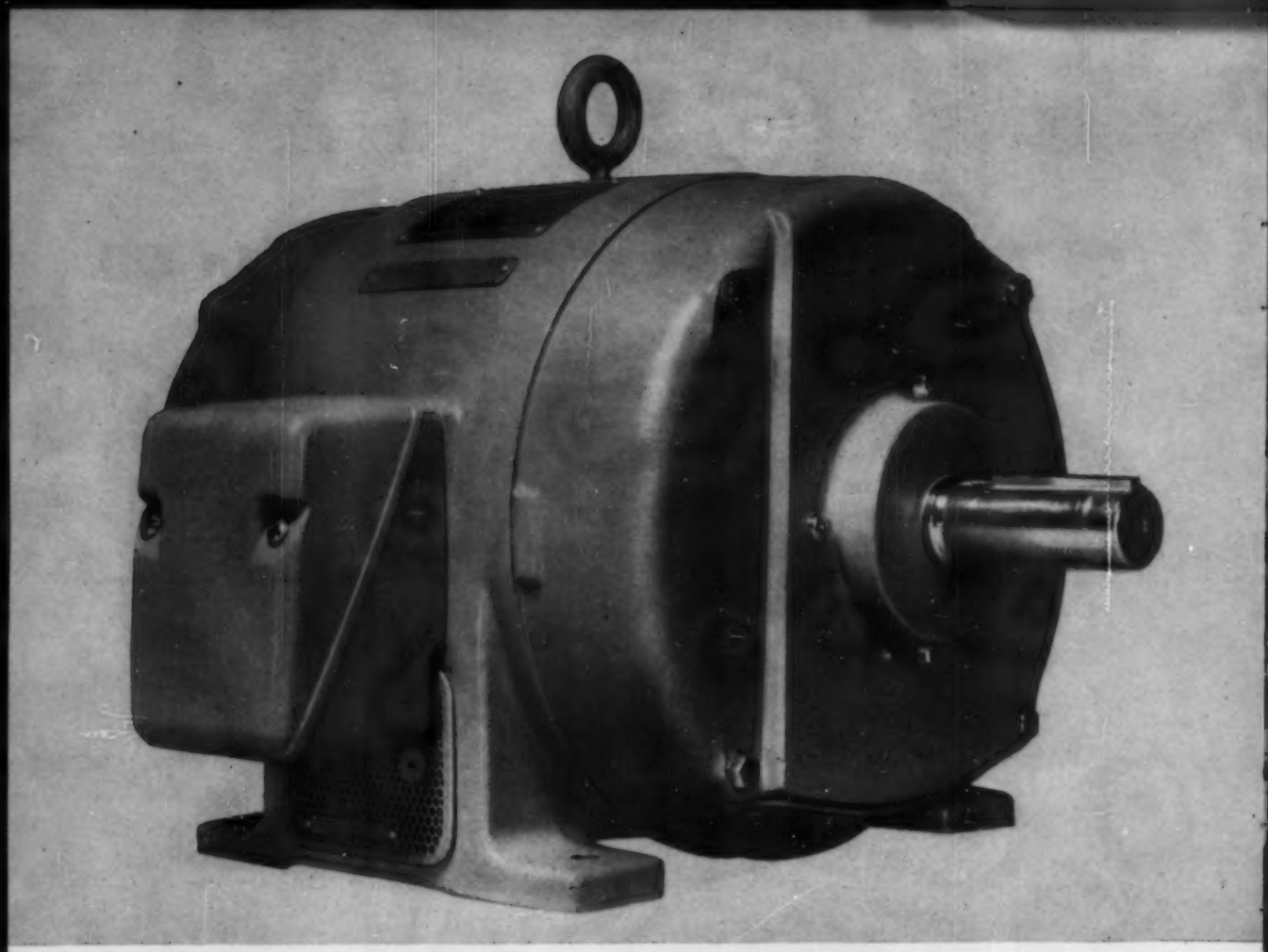
EVEN BIGGER RIGS FOR OFFSHORE DRILLING being asked for by operators, some of which have suffered blowouts and fires. Current requests are for 3000 hp rigs for ample reserve power. Principal use is for deep, high-pressure drilling off Louisiana's coast.

PARTIAL LOUISIANA OFFSHORE DRILLING agreement will be reached promptly as a result of Louisiana and Interior Department talks. The parley stems from recent state-industry lease validation agreements and proposals. Leasing in the disputed area between the 3½ and 10-mile limit may still be held up until the state's seaward boundary can be decided.

INTERSTATE OIL PRODUCTION PROGRAMMING will continue without government interference for months to come. Study of antitrust aspects of interstate compacts, short of time and money, revealed little. Congress last year demanded report, but later trimmed budget to a point where continuation of the survey was impossible, says Attorney General Herbert Brownell.

HIGHER PIPE PRICES will be paid on orders coming from Eastern steel mills, as manufacturers were forced to cancel 70,000 lb East-to-Southwest freight rates. In the past, major Eastern mills had equalized freight rates with the Southwest and Rocky Mountain mills. The change, which favors area mills and barge operators, leaves a 40,000 lb rate of $1.38 per hundred, the lowest currently in effect. The higher rate had laid down pipe at Houston at 74 cents per hundred weight.

MORE MERGERS of independent oil firms into major companies is foreseen by industry observers. Reason for the sell outs may be found in the dissatisfaction raised by higher costs, lower crude prices, decreasing per-barrel discoveries, declining allowables and rising imports.



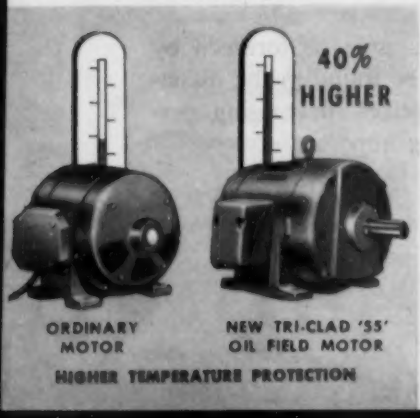
General Electric's NEW

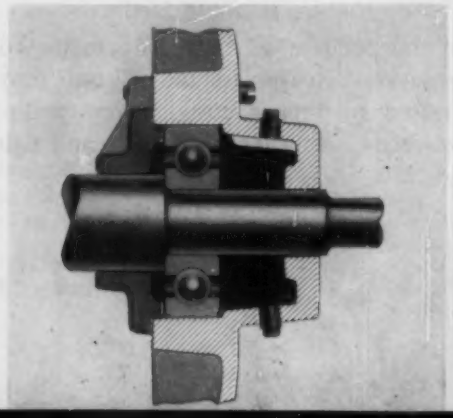
INSTALL IT...

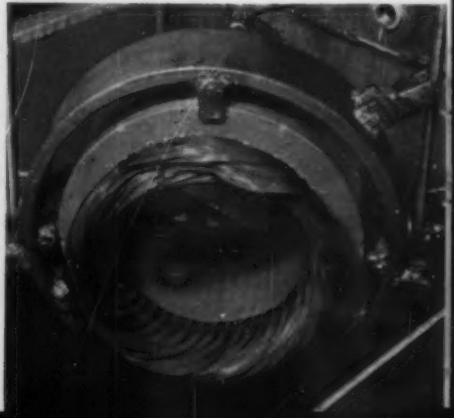
HEAT PROTECTION—Alkanex*, a revolutionary new wire enamel used in the field windings, allows up to 40% higher temperature rise than is possible in ordinary motors, virtually eliminates burnouts.

DUST PROTECTION—Closely machined bearing caps and housing on each side of bearings, plus the new G-E Tri-Clad "55" oil field motor's low velocity air intake system, keep dirt and dust out of vital parts, help give added protection for longer, trouble-free operation.

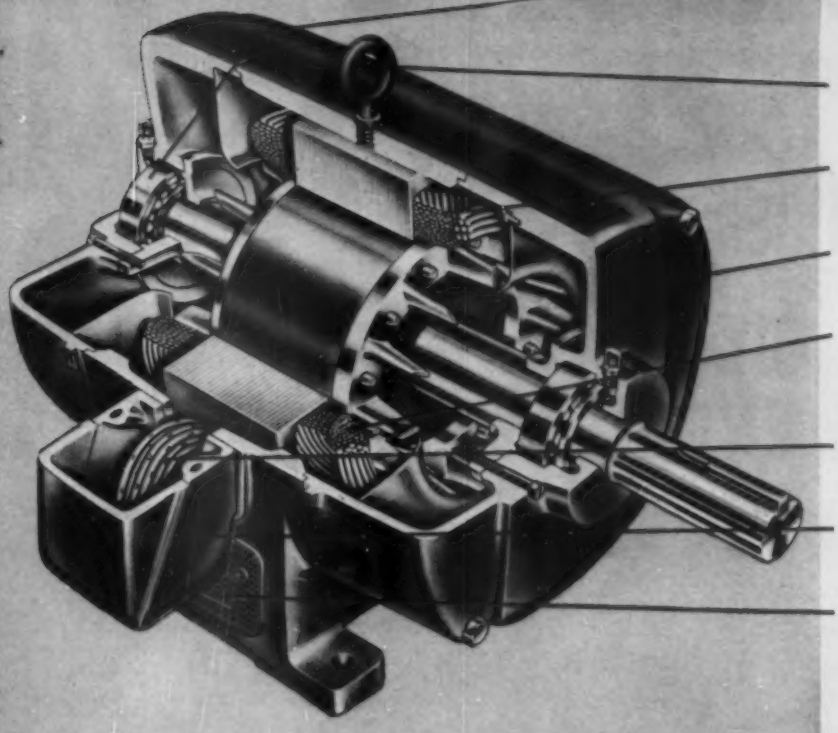
MOISTURE PROTECTION—Field windings, coated with water-shedding silicone Dri-Film*, plus cast-iron frame construction and close fits between all joining surfaces, help prevent motor failure due to moisture.







PACKED WITH MONEY-SAVING FEATURES



1. Advanced bearing system will last longer without regreasing than any other motor bearing system.

2. Convenient eyebolt cuts installation time, —permits easier handling.

3. Water-shedding stator windings virtually eliminate breakdown due to moisture.

4. Rugged cast-iron frame helps prevent corrosion and accidental damage.

5. Class 'B' insulation system with revolutionary Alkanex* wire enamel allows up to 40% higher temperature rise.

6. Perma-numbered leads are easy to read even when taped or clipped.

7. Easy-access conduit box is large and roomy for fast wiring.

8. Removable screens protect motor against damage from rodents and rocks.

*Registered trade-mark of General Electric Company.

TRI 55 CLAD oil field motor

REG U.S. PAT. OFF.

FORGET IT!

General Electric's all-new Tri-Clad "55" oil field motor is specially designed and engineered for long, trouble-free operation on rugged, outdoor pumping applications.

This motor will run far longer without attention than ordinary motors because it is protected against heat, dust and moisture. Burnouts have been virtually eliminated by the use of Class 'B' insulation made from new "miracle" materials Alkanex, heat-resistant enamel wire, and Mylar† mica-glass laminate slot and phase insulation.

The high heat resistance of this new insulation means you get more horsepower per pound in a more compact, cast-iron frame, because of higher temperature protection possible with Alkanex. The large grease reservoir and revolutionary bearing system has reduced normal maintenance to a few minutes every five years.

The eyebolt, large roomy conduit box and perma-numbered leads—"extras" at no extra cost—cut installation time to a minimum.

A new G-E oil field motor on your pumping rig is easily your most economical buy. Install it . . . forget it. For more information write for Bulletin GEA-6546 or contact your nearest General Electric Motor Distributor, or G-E Apparatus Sales Office. 877-1

†DuPont trade-mark

MEDIUM INDUCTION MOTOR DEPARTMENT

Schenectady 5, New York

Progress Is Our Most Important Product

GENERAL ELECTRIC

NORDBERG

POWER CHIEF® OIL FIELD ENGINES

FOR PRODUCTION PUMPING

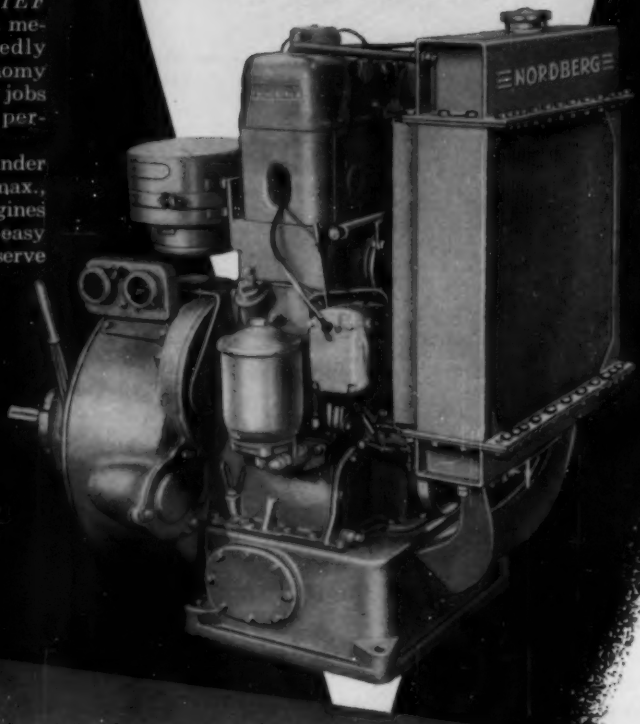
Nordberg *POWER CHIEF* Gas Engines are low cost, medium speed units, ruggedly built for maximum economy on production pumping jobs where 'round-the-clock performance is a must.

Available in 1 and 2-cylinder sizes, up to 36 hp max., *POWER CHIEF* Gas Engines are simple to install and easy to maintain—ready to serve you 24 hours a day.

FOR RIG LIGHTING

More and more rigs are being lighted by Nordberg *POWER CHIEF* Diesel Generator Sets . . . because these sturdy units stand the gaff of continuous service, night after night, without constant attention and maintenance.

Built in 1, 2 and 3-cylinder sizes, from 10 to 45 hp, 6 to 30 kw—*POWER CHIEF* engines are available with special vibration-proof mounting for rig installation



NORDBERG MFG. CO.
Milwaukee, Wisconsin

SEND FOR NEW BULLETIN

NORDBERG
DIESEL • DUAFUEL® AND SPARK IGNITION GAS ENGINES

Available at your local Supply Store or contact these Authorized Distributors:
SOUTHERN ILLINOIS—Stephens Oil Field Repair, Fairfield, Illinois
KANSAS—Mead Engine & Welding Works, Sterling, Kansas
OKLAHOMA—Cornelison Engine Maintenance Co. Inc., Seminole, Oklahoma
HOUSTON & GULF COAST—Diesel Engine & Equip. Service Co., Houston, Texas
LOUISIANA & MISSISSIPPI—Rogers Diesel Engineering Co., New Orleans, La.
WILLISTON—Tractor & Equip. Co., Sydney, Montana
COLORADO—JULESBURG—Mead Engine & Welding Works, Sterling, Colorado
SOUTHERN CALIFORNIA—In-Mar Co., Wilmington, California

OG

NORDBERG MFG. CO., Milwaukee, Wisconsin

Send New Bulletin 239A covering *POWER CHIEF* Oil Field Engines to:

Name.....Position.....
Company.....
Address.....
City.....Zone.....State.....

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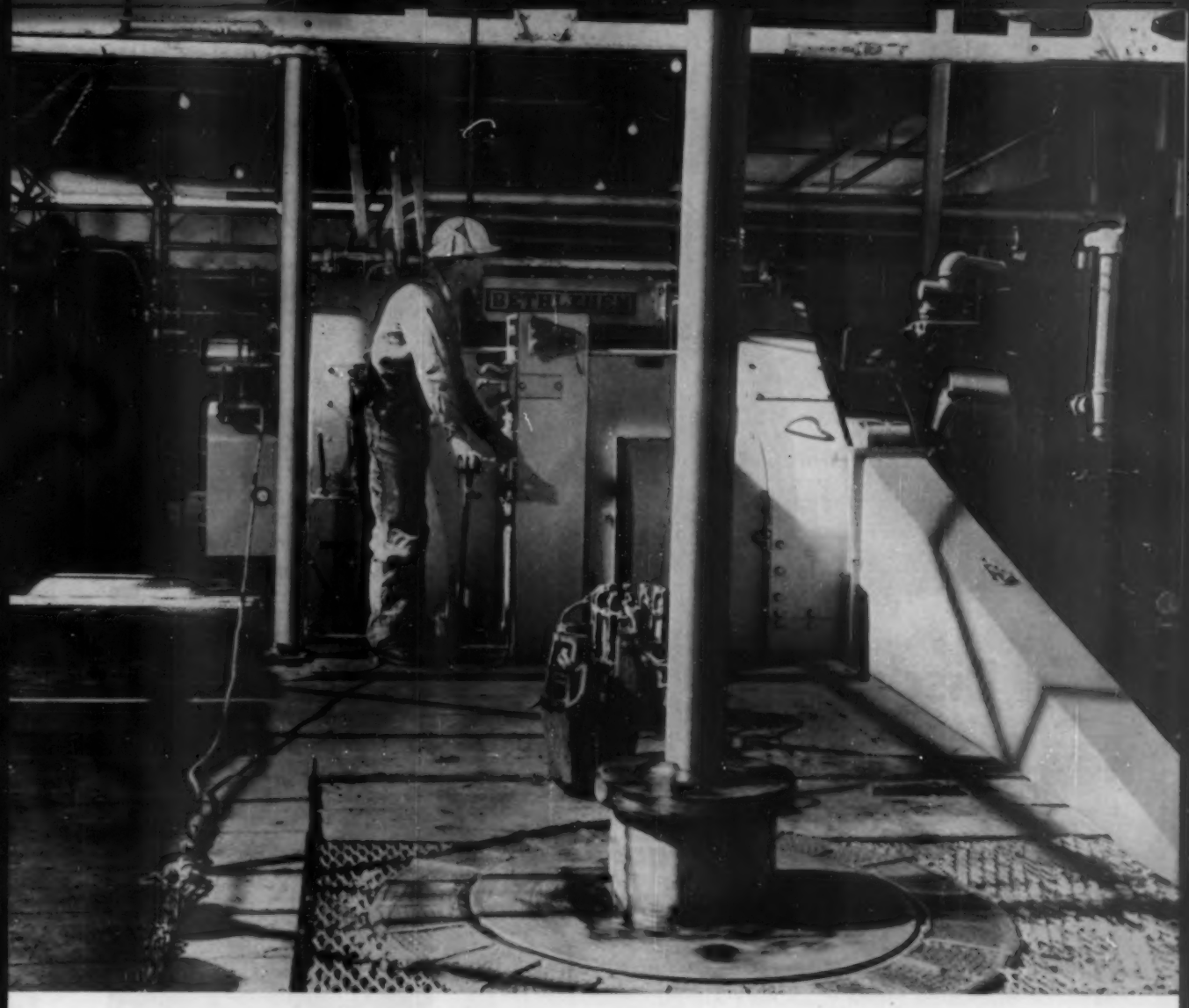


Making Hole Fast in West Texas

This husky Bethlehem drawworks was photographed making a lot of hole in West Texas. It's an M-810 for medium-deep drilling, and here it was keeping things very much on the go. You will always find this typical of the M-810, a rugged unit with exceptionally high clutch capacity (low-speed drum clutch, 102,000 ft-lb torque at 100 psi!). The rig can be furnished with mechanical drive, fluid coupling, or torque-converter; sectionalized engine compound is standard.

For depths in the medium range, Bethlehem offers a similar but smaller drawworks, the M-58. It too has very high clutch capacity: low-speed drum clutch, 59,000 ft-lb torque at 100 psi. In its size class there is no sturdier unit built. Compound is of sectionalized type so that the rig can be broken down into loads of required road widths. Drives: mechanical, fluid-coupling, or torque-converter.

Both the M-810 and the M-58 are standouts in their respective drilling ranges. For full particulars and operating data, we suggest you call our nearest office.

BETHLEHEM SUPPLY COMPANY
General Offices: 21 E. Second St., Tulsa, Okla.
West Coast Headquarters: Los Angeles, Calif.
Export Distributor: Bethlehem Steel Export Corporation
25 Broadway, New York, N. Y.

BETHLEHEM SUPPLY

Twin Disc's new SP-321 PTO

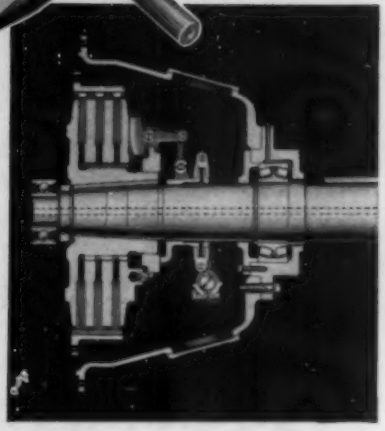
meets increased power requirements of modern industrial engines

Increased rpm. . . . increased hp output—that's the trend among industrial engine manufacturers. And that's where Twin Disc comes into the picture with its new SP-321 Power Take-Off—a friction clutch designed to meet the increased power transmission requirements of today's higher speed, higher horsepower industrial engines.

Unusually compact for its high capacity, this new PTO can handle up to 6730 lbs.-ft. of torque and transmit up to 602 hp at 1550 rpm. It's available with a standard SAE No. 00 flywheel housing adapter to meet the widest range of industrial power units in its hp and rpm ratings.

Other features include a triple driving-plate construction to provide ample friction surfaces to withstand excessive heat . . . a pilot bearing with double-width bearing race for greater lubrication retention and long life . . . and a spherical roller bearing at the clutch output shaft for greater overload and side-pull capacity.

The new SP-321 Power Take-Off —along with the recently announced SP-318 and SP-314—makes the Twin Disc line of heavy-duty friction power take-offs *the broadest, most complete line available.* For full information, write Twin Disc Clutch Company, Racine, Wisconsin. Request *new* Bulletin 308.



Twin Disc's new SP Power Take-Offs feature: counter-balanced engaging linkage; positive-type clutch engagement; pilot bearing with double grease shield; clutch plates with maximum friction area; spherical roller bearing; heavy-duty, oversize output shaft; easily adjusted clutch through pin and adjusting ring.

TWIN DISC

TWIN DISC

Friction Clutches and Fluid Drives

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin • HYDRAULIC DIVISION, Rockford, Illinois

BRANCHES OR SALES ENGINEERING OFFICES: CLEVELAND • DALLAS • DETROIT • LOS ANGELES • NEWARK • NEW ORLEANS • TULSA

LUCEY Export

REDDAWAY

OIL FIELD

Brake Blocks

Give you

- smoother, safer feed-off
- longer drilling life
- less wear on brake flanges
- faster installation time
- greater operating economy

Top quality Reddaway Oil Field Brake Blocks and Linings—metallic or non-metallic—are the choice of experienced drillers all over the world . . . because they provide the greatest combination of values of any comparable product! Smoother, more uniform friction always guarantees even, *safer* feed-off at all times under operator's direct control . . . *allowing more hole drilled per brake horsepower.* Reddaway brake blocks and linings *last longer* . . . put *less wear* and tear on your brake flanges . . . and *stay tight* because their bolt holes are doubly reinforced. Accurate sizing and drilling to close tolerances insure *faster installation, too!* For real operating economy over all types of drilling conditions, join the drillers who *know* . . . order Reddaway Brake Blocks from Lucey Export for your next job.

Reddaway "QUICK CHANGE" Rotary Blocks Also Available—Now you can bolt on Reddaway's rugged rotary blocks from the outside without removing the brake band! Crewman simply slides replacement block between band and drum and tightens bolts from the outside of the band. Drum is ready for operation in *70 per cent less time.* Special "SHAKE PROOF" nuts are firmly embedded in the block. The Reddaway is the only *bolt-on* type block that can be installed without removing the band. The brake bands therefore *cannot spring out of shape.* Either "Standard" or "Quick Change"—REDDAWAY BRAKE BLOCKS serve you BETTER!

Here's why

REDDAWAY MEANS BETTER BRAKE LININGS

Minimum cotton in asbestos cords eliminates carbonizing and glazing that cause erratic friction and lining failure.

Deep-penetration curing and impregnating in vacuum autoclaves produce a denser, more uniform brake block that resists heat, moisture, and oil . . . without excess volatiles that cause unpleasant odors.

Quality-control engineering gives precise degree of density and firmness to prevent grabbing and slipping. Standing and running friction are virtually identical, providing perfectly controlled braking on even the heaviest pipe.

Controlled hardness keeps metal splinters from imbedding in the lining . . . prevents major cause of brake flange scoring.

Scientifically designed brass ferrules and brass reinforcing wires assure double protection against loosening of Reddaway Brake Blocks in service.

Uniform construction, designed and drilled exactly to specifications . . . a size to fit every popular rig in current use.

Exclusive Exporters of Reddaway Brake Blocks

LUCEY Export

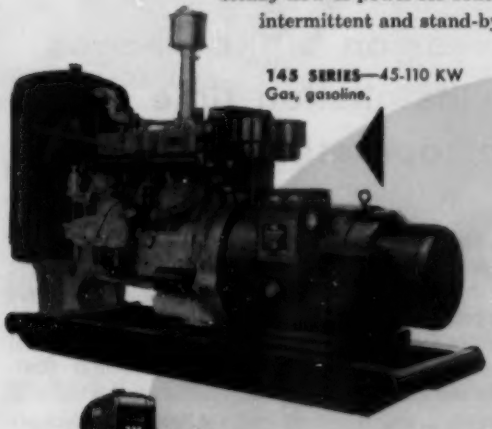
233 BROADWAY, NEW YORK 7, N. Y.

NOW— a complete line of
WAUKESHA
Industrial ENGINATORS®

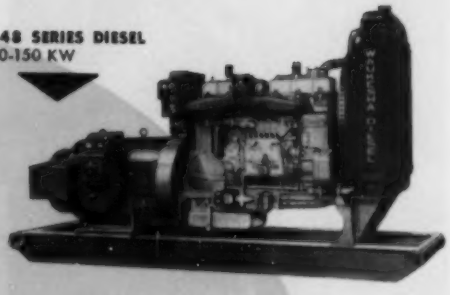
Waukesha now offers you a superb line of Enginators—backed by half a century of experience in building heavy-duty internal combustion engines and electrical equipment. Designed for reliable performance on all types of fuel, these Waukesha power units supply accurately balanced engine and generator combinations in applications requiring a smooth, steady flow of power for continuous, intermittent and stand-by duty.

50-600 KW • NATURAL GAS LPG • GASOLINE • DIESEL

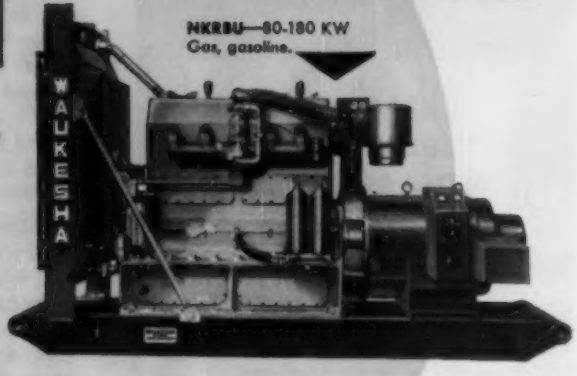
145 SERIES—45-110 KW
Gas, gasoline.



148 SERIES DIESEL
50-150 KW

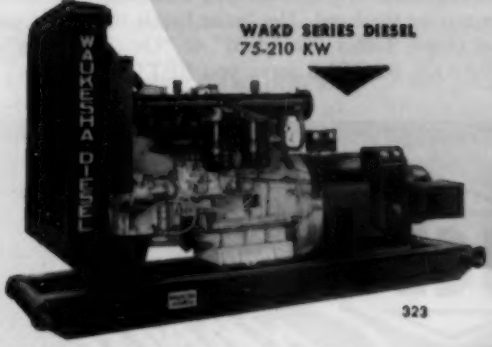


NKRBU—80-180 KW
Gas, gasoline.



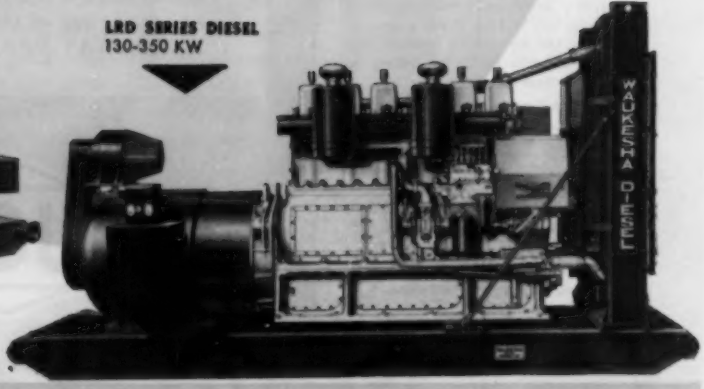
WAK SERIES—75-170 KW
Gas, gasoline.

WAKD SERIES DIESEL
75-210 KW



323

LRD SERIES DIESEL
130-350 KW



WRITE FOR BULLETINS FOR THESE AND OTHER MODELS.

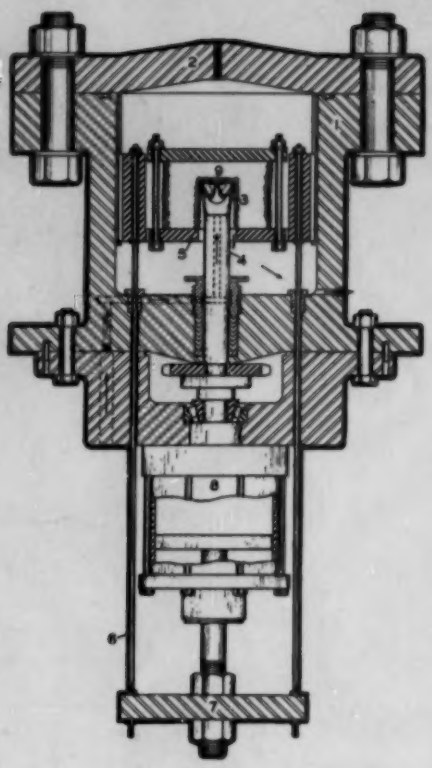
WAUKESHA MOTOR COMPANY • WAUKESHA, WISCONSIN *RAILWAY DIVISION*

Little bits prove some big points:

- Mud column pressure makes rock harder to drill.
- Filter cake slows and at times virtually stops penetration.
- Jets — with proper velocity — minimize the effect of filter cake on bottom.
- Penetration rate and bit footage can be vastly increased when air and gas are circulated.

Regular and jet micro-bits used in Hughes pressure research.

This core half-section shows what happens in porous formations when pressure conditions cause filter cake to form.



Cross-section of micro-bit pressure chamber and, below, special drilling rig developed by Hughes engineers for pressure research.

Hughes research shows effect of mud column pressure on drillability of rock formations

We have long been curious to know *why* penetration rates decline as wells go deeper, and *why* some soft formations become difficult to drill.

In the search for these elusive *"whys"*, Hughes engineers designed and built a micro-bit drilling rig capable of developing pressures from zero to over 10,000 psi. In hundreds of laboratory drilling tests — many correlated with wells drilled in the field — we established that in most formations *drillability decreases as mud column pressure increases.*

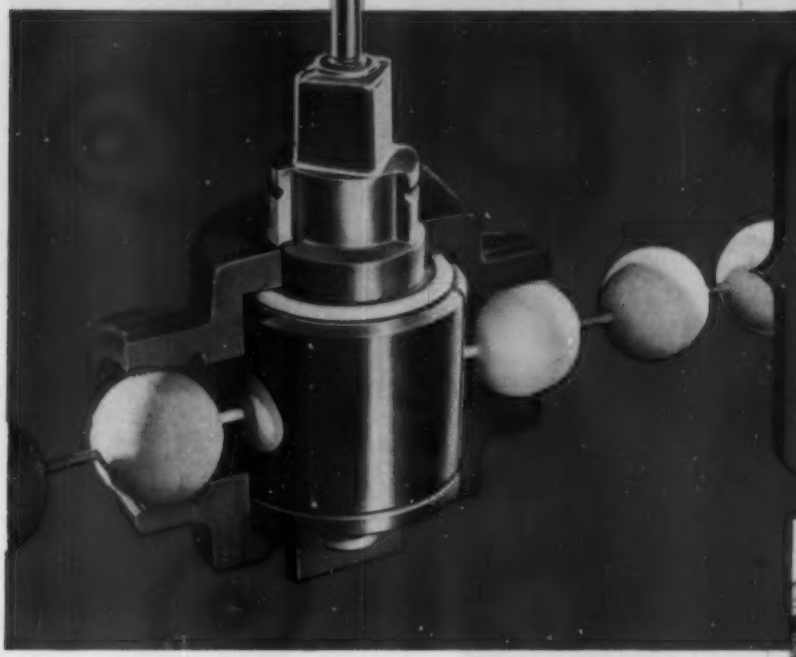
We also found that when filter cake forms in soft, porous formations, jets having sufficiently high velocity can substantially accelerate the rate of penetration.

These important facts have helped to better define penetration problems and point the way to future gains. Further increases in penetration rates — vastly improved in recent years — is the continuing aim of HUGHES research, now in its 46th year.

HUGHES TOOL COMPANY

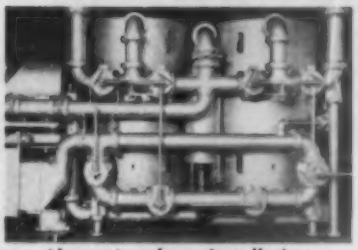
HOUSTON, TEXAS

acf Lubricated Plug Valves



ROUND PORT MEANS FREE FLOW ALL THE WAY

In salt water disposal plant.



Absorptive dryer installation.

In natural gasoline plant.

You get full volume, unrestricted flow throughout the entire piping system when you use acf Round Port Valves.

The pipe-matching port openings cause no loss in head pressure—offer no more resistance to flow than the pipe itself. There are no obstructions—no turbulence and no harmful abrasive effects from solids in suspension. Even the most heavy viscous ladings flow freely through acf Round Port Valves.

Split-second quarter-turn shutoff, non-wedging cylindrical plug, Teflon* head gasket, are additional advantages that add to perfect performance of acf Round Port Valves—that mean extra long trouble-free service—lower maintenance costs and fewer work stoppages.

Act now to step up valve performance—to keep maintenance costs down. Representatives in 50 principal cities.

* DUPONT TRADE NAME

W-K-M MANUFACTURING COMPANY, INC.

A SUBSIDIARY OF acf INDUSTRIES INCORPORATED

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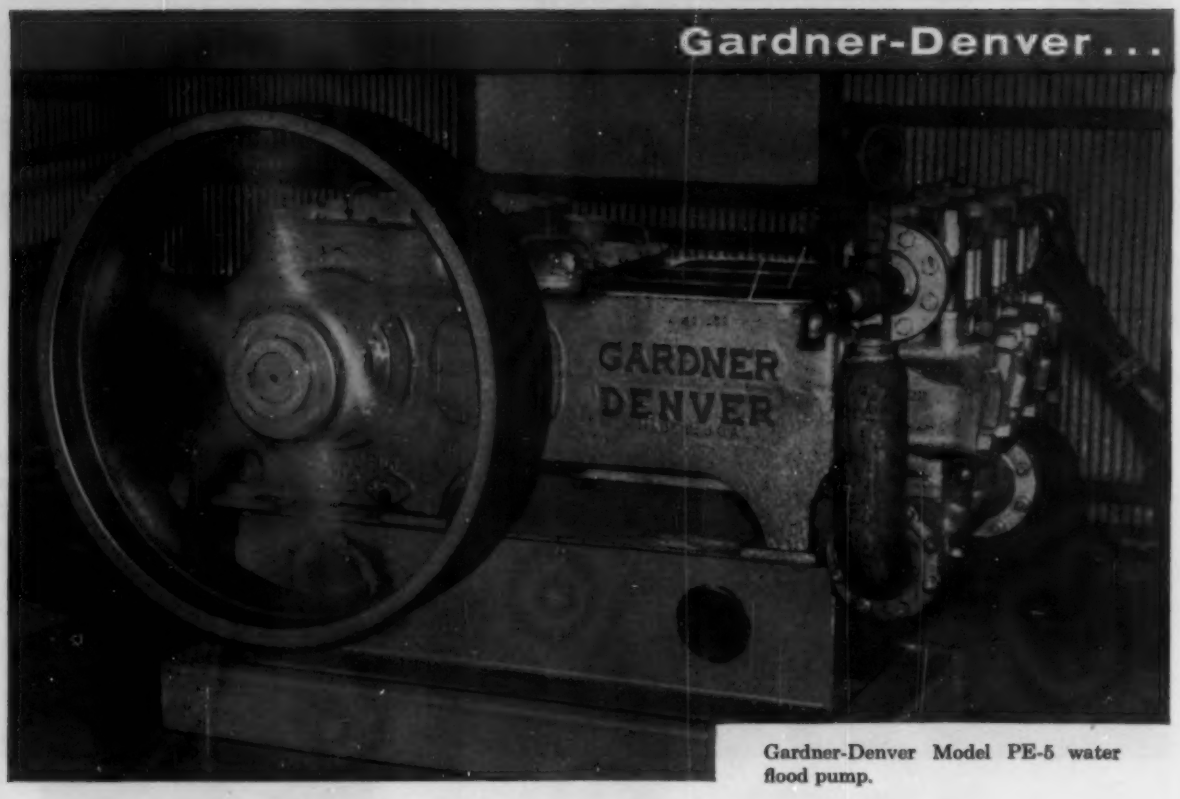
MANUFACTURING

W-K-M THROUGH-CONDUIT GATE VALVES

acf LUBRICATED PLUG VALVES

KEY RETURN BENDS AND FITTINGS



Gardner-Denver Model PE-5 water flood pump.

GARDNER-DENVER gives oilmen what they need in water flood pumps

Select the pump for the job from the complete Gardner-Denver quality line . . . all specially engineered for salt water disposal and water flood service.

And speaking of service, Gardner-Denver service specialists are located in:

Pittsburgh, Houston, Corpus Christi, Odessa, Wichita Falls, New Orleans, Tulsa, Los Angeles, Shreveport, Oklahoma City, Ellinwood, Casper and Edmonton.

CONDENSED SPECIFICATIONS

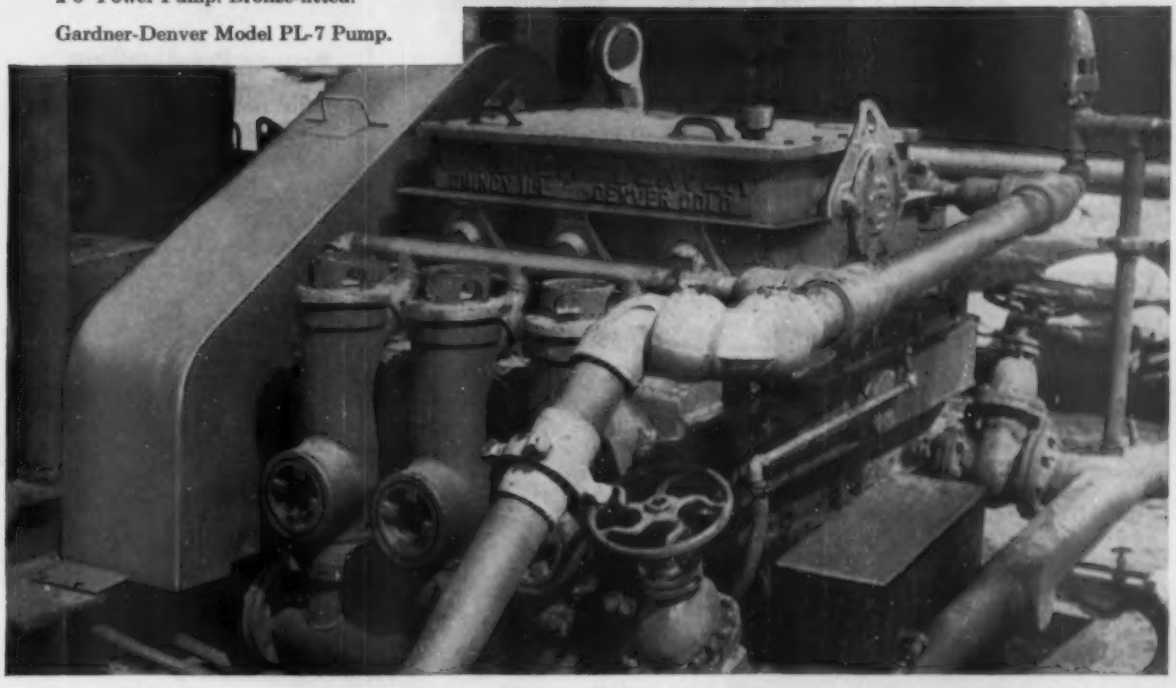
MODEL	PL-7	PA-8	PE-5	FG-FXG	FF-FXF	LE-LXE
Input hp—up to	240	160	75	60	40	24
Discharge psi up to	3360	1455	2700	895	640	820
Bbl. per day up to	13,200	9000	7300	6000	4500	3000

Send for detailed information

Serving the World's Basic Industries

Gardner-Denver Model FG-FXG 4½" x 6" Power Pump. Bronze-fitted.

Gardner-Denver Model PL-7 Pump.



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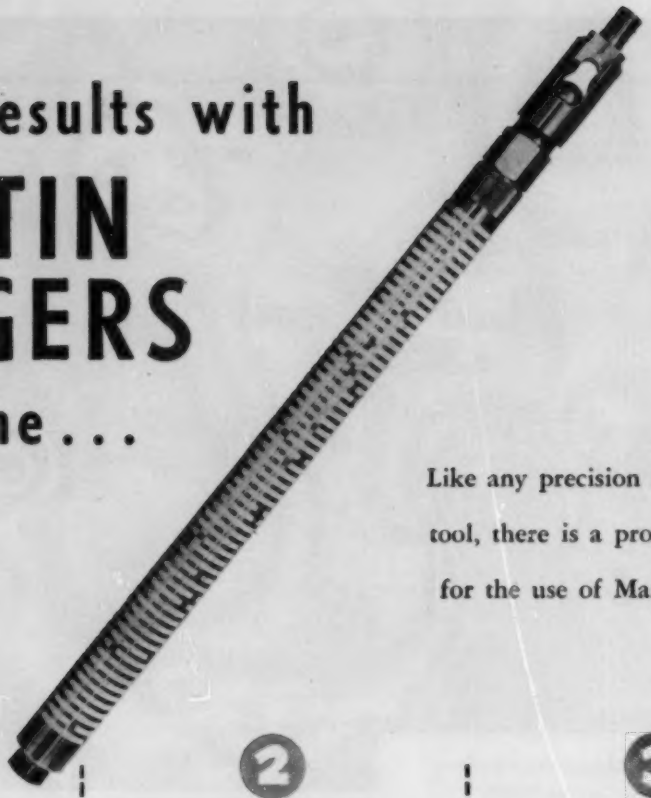
Perfect Results with MARTIN PLUNGERS everytime . . .



Like any precision instrument or tool, there is a proper technique for the use of Martin Plungers.

1

Proper Plunger Length

The deeper the well the longer the plunger required. Three rings per 100 ft. for the 1¼" and smaller diameters, and two rings for the larger diameters, is simple rule to follow. Add extra length for stroke-thru.

2

Proper Ring Size

Gravity, Temperature and water content determine the ring size to give free travel with minimum slippage. There is no reason to have a stuck plunger, or too loose a fit. You can have any desired fit by steps of .005".

3

Proper Pre-swelling

Why run Martin Split Rings dry, when pre-swelling will get much better results? Even lube oil or grease will tighten them in the grooves, and when rolled down and tight you are assured of trouble free operation.

Complete, detailed instructions for using Martin Plungers are given simply and quickly in John N. Martin Catalog No. 4. All guess work is eliminated. You obtain proper ring size for a correct working fit, proper plunger length for your particular well, and proper pre-swelling of rings. *It's a fact: — you have perfect results with Martin Plungers everytime — regardless of water or sand conditions — when you follow the simple instructions in John N. Martin Catalog No. 4. Write for it today.*

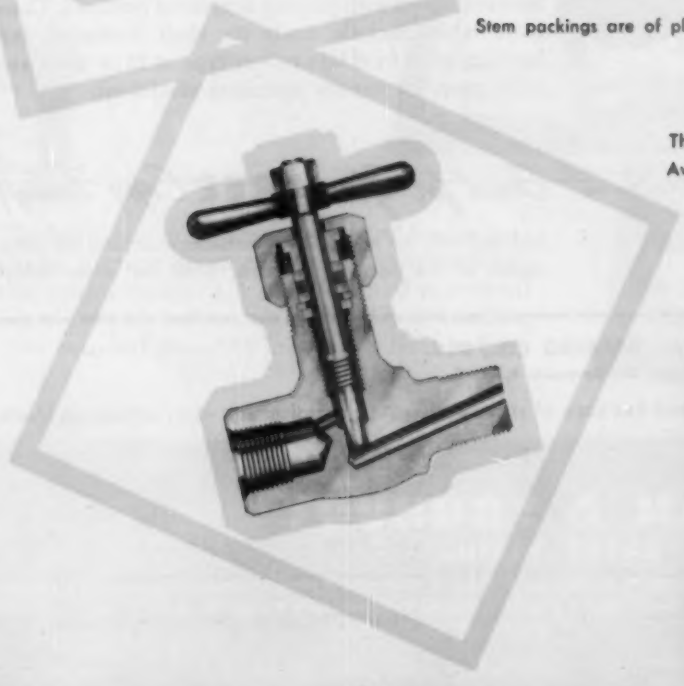
MARTIN PLUNGERS ARE SOLD THRU SUPPLY COMPANIES

JOHN N. MARTIN

Manufacturer

9 W. BRADY • TULSA, OKLA.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD



Go First-Class on All Your Needle Valves, too

For high pressures . . . for low pressures . . . in all types of Christmas Trees, O-C-T Needle Valves have been tested and proved to be unquestionably the safest, strongest ever built.

O-C-T Needle Valves feature one-piece alloy steel bodies, welded bonnets for maximum safety and a multi-compound, non-crushable V-type packing especially developed to cope with those high pressures and high temperatures.

Stem packings are of plastic asbestos and aluminum foil compound suitable for 15,000 and 30,000 psi hydrostatic tests.

Each valve is subjected to a compressed air test under water before approval by inspectors.

The best in pressure gauge needle valves is by O-C-T!

Available through more than 700 supply store outlets.

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Chock-Full of Useful Information on How to Select ROLLER BEARINGS

- **Reflects latest RBEC* standards and formulas, PLUS the latest research of Rollway engineers.**
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CAPACITIES Detailed information on radial static capacities, radial dynamic capacities, and thrust capacities of cylindrical radial bearings.

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- 14 FOOT STROKE
- 35000 LB. CAPACITY
- 912000 IN. LB. PEAK TORQUE

To fulfill the ever growing demand for longer stroke, greater beam capacity, and more effective counterbalance, Lufkin is proud to present this giant new unit which is capable of handling the heaviest pumping jobs in the field today.

The design of this new 14-footer features the same well known RUGGEDNESS and DEPENDABILITY which has made LUFKIN units the standard of comparison the world over.

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and to everyone in the Oil Industry—we say, "THANK YOU"!

The Oil Industry has a reputation for being rough, tough, demanding. But we of PGAC have ample reason to know that no other industry so loyally rewards meritorious and dependable service. ☆ On October 15th, 1946, our business was started in quarters covering only some 500 square feet. In the ensuing ten years our services were so widely accepted that our two plants in Houston now occupy over 40,000 square feet of floor space. ☆ PGAC serves the oil fields in this country, and through three subsidiary companies serves Canada, Venezuela and Germany. Forty offices and stations, and an efficient staff of over 600 devoted and experienced technicians, provide 24-hour service daily for the logging and perforating of your wells. ☆ We believe our progress is largely the result of our development and first use of so many outstanding perforating and logging techniques during the past ten years. And it is our intention that PGAC's leadership in research, engineering, safety and service—while complimented by imitation — shall never be equalled!

PGAC-568

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No. 3 of a series on how Grant specializes in one job: Building the tools that help you drill wells better!

TAKE A LOOK AT THE LOG!

Drillblade Stabilizer

There's where you'll find the FACTS on GRANT DRILBLADE STABILIZER PERFORMANCE...

FASTER PENETRATION RATES because the Grant Drilblade stabilizes and centers the string to permit *more weight on the bit without increased hole deviation.* You'll find fewer round trips in the log, too. And you'll see

LESS DRILL COLLAR WEAR in high angle hole because the Grant effectively centers and stabilizes those long collar strings to prevent wear against the hole wall. Look in the log also for

BETTER HOLE CONDITIONING in rough formation. The Grant has three husky blades that give far *more* bearing area. Blades stay in gauge longer . . . provide better support in soft formations . . . smooth out rough spots left by the bit in loose formation. Check the log for

GREATER DRILLING SAFETY because the hollow construction of the blades permits easy mill-offs with the same rotary shoe you use to free your string if it becomes stuck in the hole. You safeguard your string when you run the Drilblade!

Model 1540 Wall Scraper

Underreamer

Cushion Stabilizer

Model 1530 Regular Reamer

Model 8480-A Reamer Near Bit Type

Made in two types—the near-bit type for directional work, and the up-string type for all stabilizing requirements in the drill collar and pipe string. Available with a wide variety of blade sizes for precise control in directional drilling. These give you *all* the dollar-saving advantages of full stabilization and faster digging with Grant. *For Drilblade details, ask your Grant service man, or write direct for Bulletin 61!*

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OIL TOOL COMPANY

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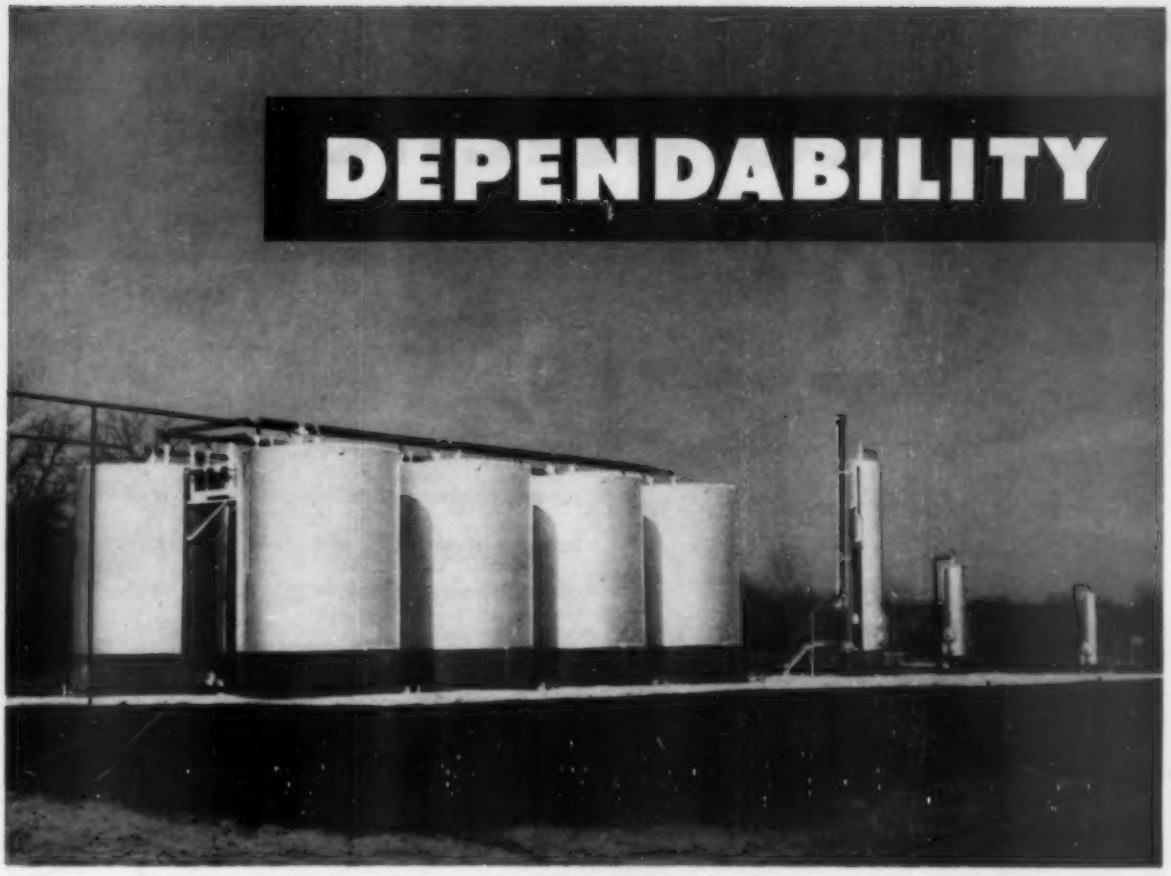

DAY AFTER WEEK AFTER MONTH AFTER YEAR

Dependability is the greatest asset lease equipment can have.

Above is a lease completed entirely with dependable Maloney-Crawford equipment.

The Maloney-Crawford lines of bolted and welded steel tanks are the best you can buy. And the M-C separators, emulsion treaters and dehydration units are among the most advanced designs on the market.

Maloney-Crawford models are available to meet any field condition or problem; and a Maloney-Crawford representative is available to discuss with you how M-C equipment can meet your needs and requirements.

MALONEY-CRAWFORD TANK & MANUFACTURING CO.

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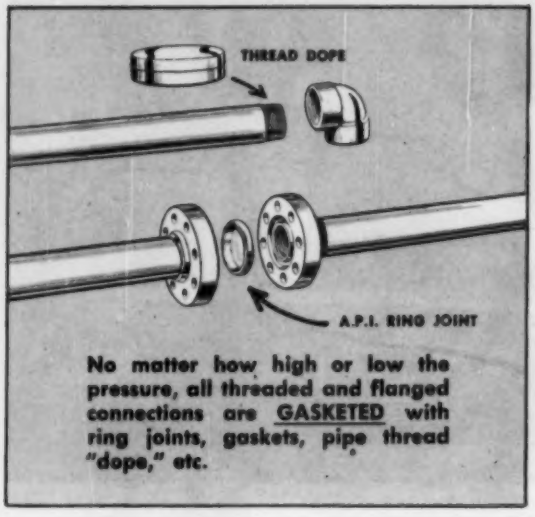
EXPORT REPRESENTATIVE: Baird Lines, 1037 Grand Central Terminal Building, New York, N. Y.
CANADIAN REPRESENTATIVE: Maloney-Crawford Tank & Service Company, Ltd., Edmonton, Alberta
TEXAS PANHANDLE REPRESENTATIVE: Atlas Tank Company, Pampa, Texas

MALONEY - CRAWFORD TANK & MFG. CO.

IT'S A FACT:

ALL TIGHT CONNECTIONS ARE GASKETED!

and tightness is important to you

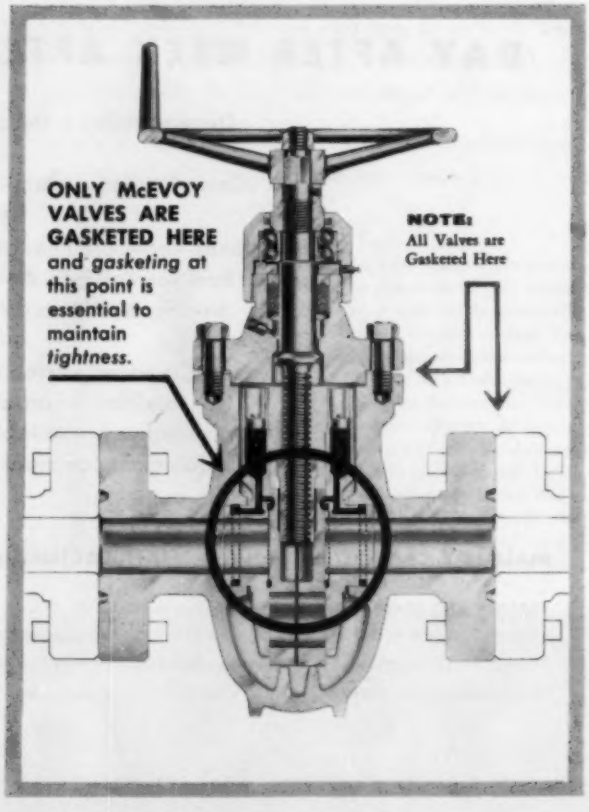


No matter how high or low the pressure, all threaded and flanged connections are GASKETED with ring joints, gaskets, pipe thread "dope," etc.

It is common practice to place ring gaskets between flanges, pipe "dope" on screwed connections, etc. to provide tightness at such joints. There is no movement between these parts, but there *is* movement between gates and seats in valves.

Valve seats and gates must remain tight. Leakage at this point is not evident from the outside. Each time the valve is operated the gates move across the seats. These movable parts *must be gasketed,* just as the bonnet, flanges or screwed ends . . . where no movement exists.

This McEvoy exclusive self-sealing system consists of two reservoirs which feed sealant, under pressure, to circular grooves between gate and seat and body and seat. This system immediately seals off any leakage that may occur, and insures outstanding tightness.


ONLY McEVOY VALVES ARE GASKETED HERE and gasketing at this point is essential to maintain tightness.
NOTE: All Valves are Gasketed Here

The full story is yours for the asking
Write for free Brochure that gives you complete information on McEvoy Valves.

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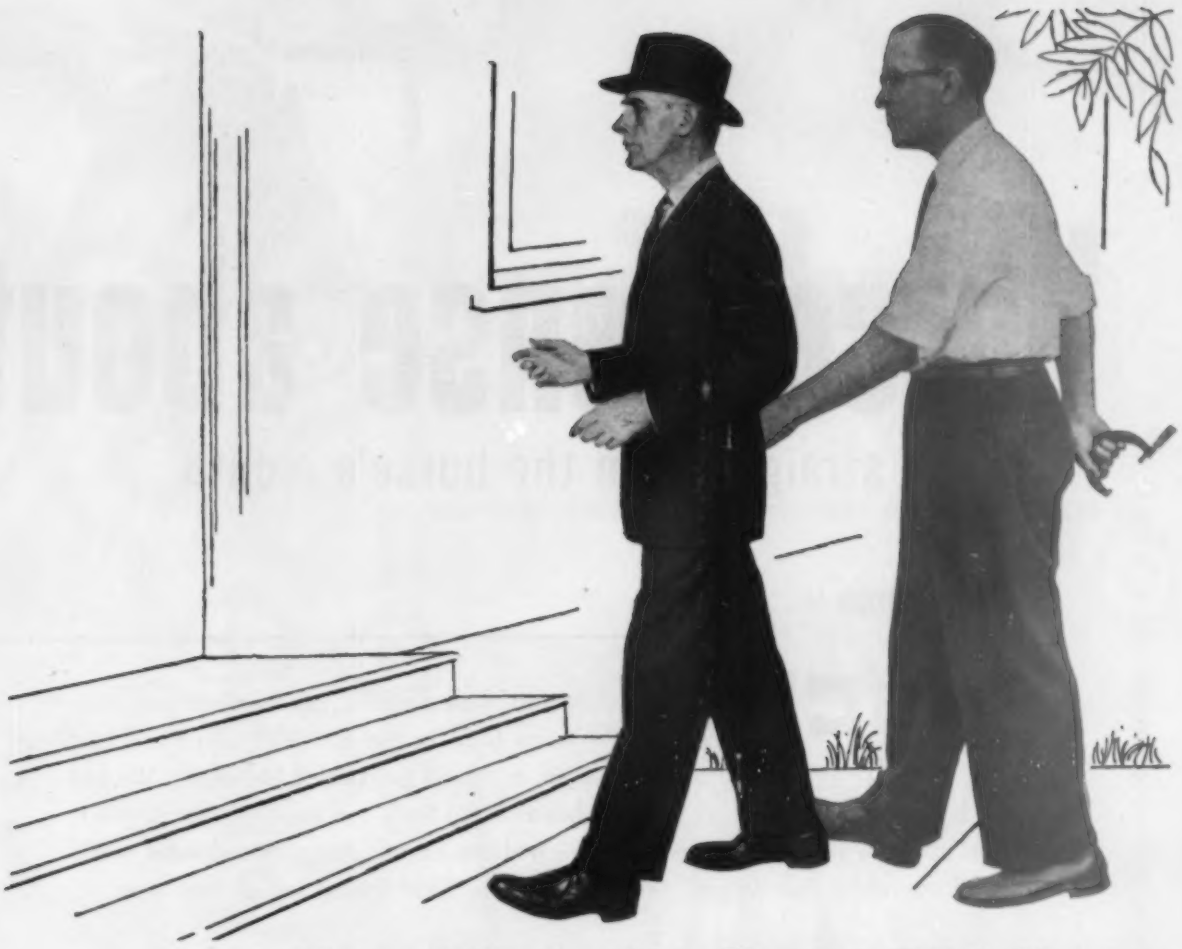


Your Wickwire Rope Distributor and our die maker... ready to serve you

This die maker—one of the skilled technicians responsible for the quality of our rope wire—is with your Wickwire Distributor every time he makes a call.

True, he's physically in our plant, working to tolerances of 1/10,000 of an inch as he fashions the super-hard carbide dies used to produce every foot of rope wire. But, whenever your Wickwire Distributor makes his call, he has the full assurance that *every* wire in the product is exactly the size it should be and has a smooth, silky surface finish. This careful attention helps assure a rope which will perform successfully.

It's just one more reason why your Wickwire Distributor knows he's got top-quality rope, slings and strand to sell . . . and that these products will serve you well.

4083

A PRODUCT OF THE COLORADO FUEL AND IRON CORPORATION

Horse Sense about

straight from the horse's mouth

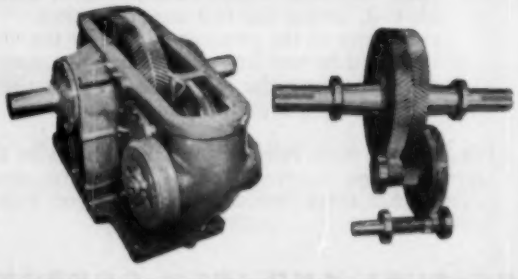
"My name is

EMSCO"

"Thousands and thousands of my brother pumping units have been bred in the EMSCO barns and put out to do a job in the oil patches of the world. We are work horses and many of us lift our heads 1½ to 5 million times a year depending on how much our master works us – without complaining. No wonder you'll find oil operators everywhere patting us on the head 'cause we're their pets.

"One reason they like us especially is our patented counterbalance which can easily be adjusted by one man working at ground level. These time-saving, wing-type counterweights pivot from the crank arms and move on semi-circular tracks. All loading is done from a pivot point and not on the track face, permitting the counterweights to move free and easy.

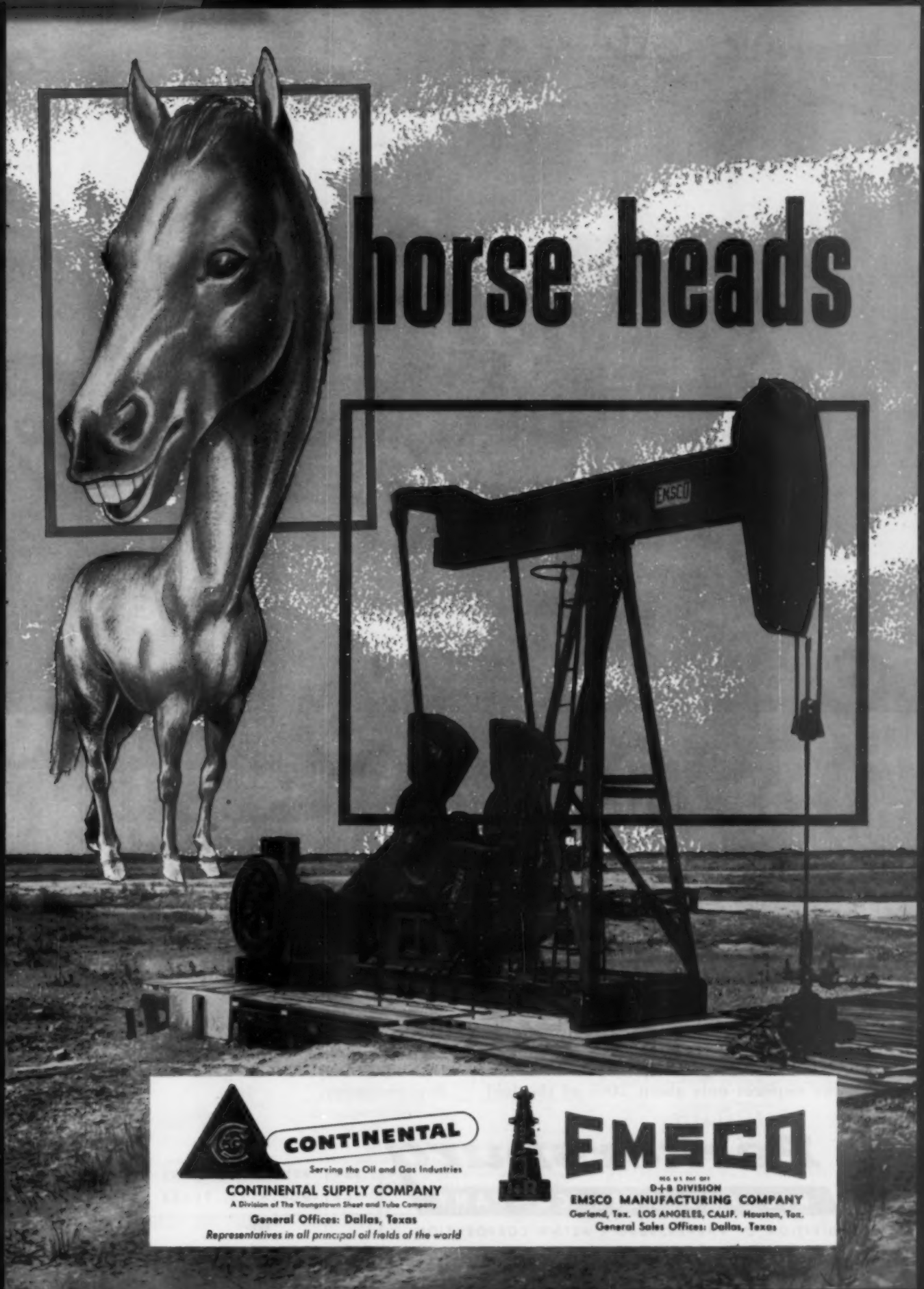
"Why don't you learn more about us? Send for a colorful bulletin or get full details from CONTINENTAL."



API Pumping Unit Gear Reducer

A new gear train arrangement gives better distribution of bearing loads, greatly increasing the life of the pumping unit. The gear train assembly is mounted in a rigid, one-piece housing – there's no split across the bearing bores to cause possible bearing distortion. Precision machined shaft openings assure perfect gear train alignment. Lubricating oil level permits the slow speed and intermediate gears to dip into oil. A combined wiper and trough system collects the oil and directs the flow to each bearing.

PT-601



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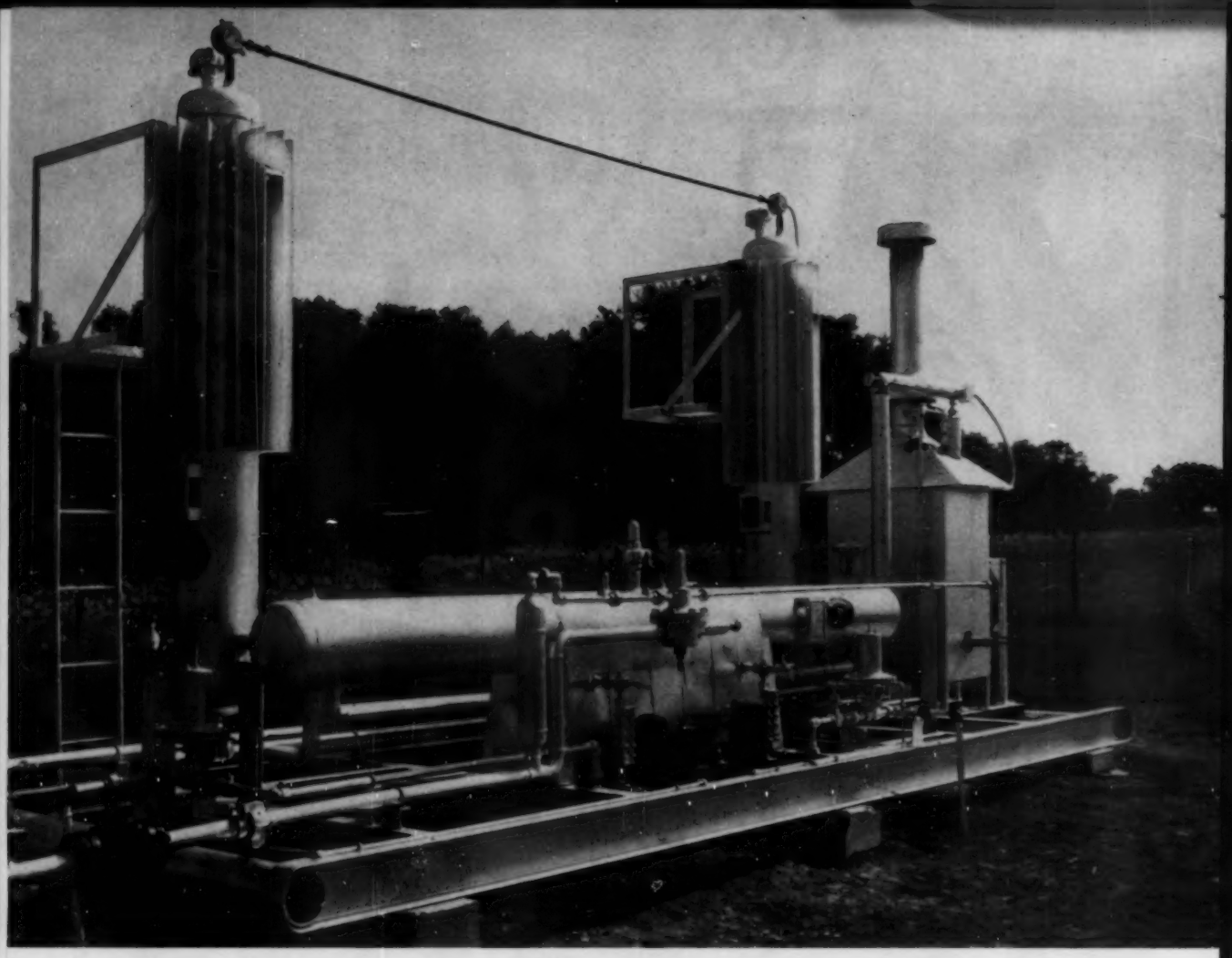

PARKERSBURG DAU WELDRIER

delivers greater dehydration efficiency -- requires ⅓ less desiccant -- uses 80% less fuel gas

Since the DAU was designed to take full advantage of the dynamics of the adsorption process, each particle of desiccant develops the maximum possible efficiency. This enables the DAU to dehydrate a high pressure gas stream with only a few hundred pounds of desiccant compared to several thousand pounds required by conventional dehydrators.

Moreover, regeneration of the desiccant packs requires only about 20% of the fuel gas normally required by ordinary dehydrators. The savings on desiccant and fuel gas alone amount to hundreds of dollars—more than enough to pay out the low first cost of the PARKERSBURG DAU WELDRIER in an unusually short time.

It will be worth your while to talk over the many advantages of the new DAU WELDRIER with your Parkersburg Representative.

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RIG AND REEL COMPANY
DIVISION OF PARKERSBURG : AETNA CORPORATION

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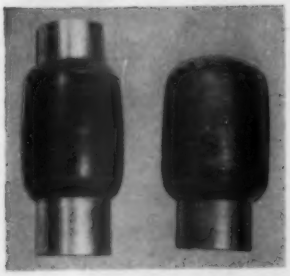
FORT WORTH 16, TEXAS

5630

Unusual step-action photo shows a neoprene protector being removed from transfer sleeve onto Kelly Sub. Entire process takes only two seconds.

"We have never lost a single protector in the hole since using NEOPRENE!"

—says PAUL A. MEDEARIS, Medearis Oilwell Supply Corp., Torrance, California



LEFT: New neoprene protector on a section of pipe. **RIGHT:** Same protector looks like new after being submerged in blend of natural and crude oil and diesel oil at 400°F. for 5½ weeks.

"In the past year, we've been supplying drill-pipe protectors made from a special neoprene compound. We have used these protectors in some of the most severe cases known to the drilling industry as far as temperatures and oil-base drilling fluids are concerned, and have never lost a single protector in the hole since using neoprene. We are extremely proud of this protector and highly recommend its use in any oil-base conditions and high temperatures."

Mr. Medearis' experience with neoprene speaks for itself. Neoprene takes the punishment of oil, abrasion, heat, sunlight—and then some! Hose, V-belts, gaskets, packings and other products give longer, more dependable service, too, when they're made of neoprene.

Next time you order, be sure to specify the synthetic rubber with extra-long service life: Du Pont neoprene.

NEOPRENE

The rubber made by Du Pont since 1932

DU PONT

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BETTER THINGS FOR BETTER LIVING
...THROUGH CHEMISTRY

AMERICAN IRON & MACHINE WORKS CO., INC.
MANUFACTURERS OF OIL FIELD EQUIPMENT
OKLAHOMA CITY

...for HIGH pump pressures

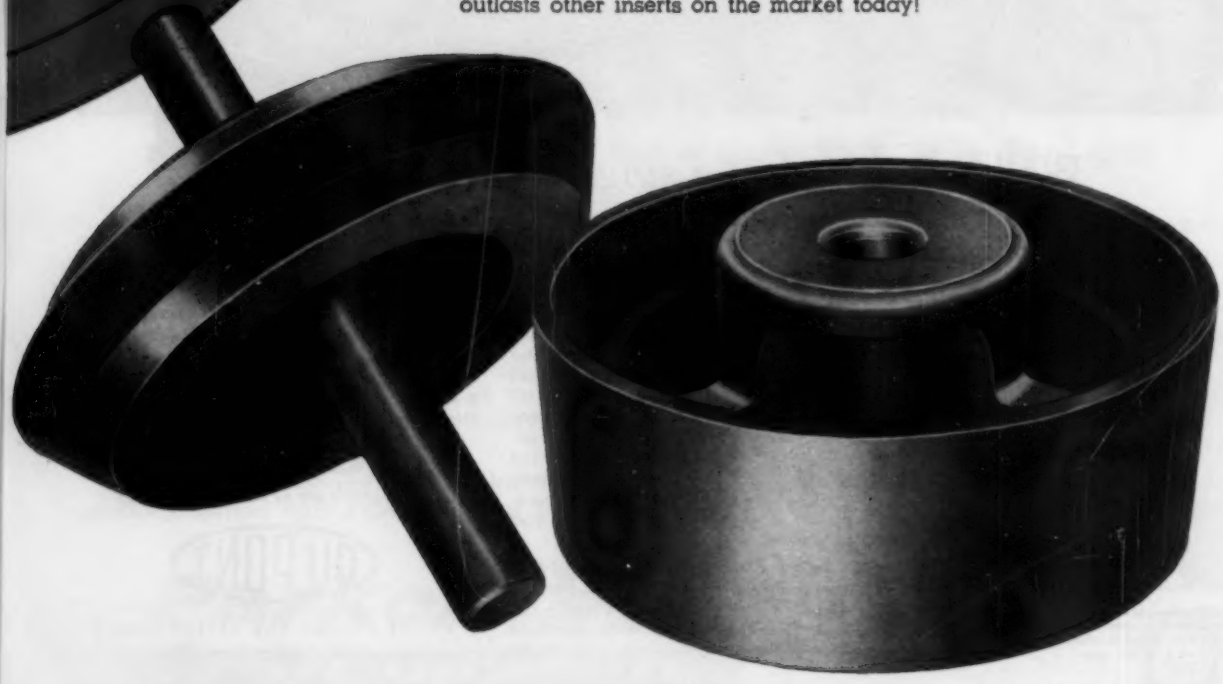
specify American Iron

Hydra-Cushion

slush pump valves & seats

American Iron Hydra-Cushion Valves and Seats operate efficiently at **all** pressures because of the **hydraulic cushion action** of the mushroom on the valve seat and the cylindrical mud chamber of the valve. The trapped mud cushions the shock of the valve on the valve seat, preventing excessive pounding out of valve on seat under high pressure.

Hydra-Cushion Valves and Seats incorporate many of the outstanding design features of the regular American Iron slush pump valve and seat . . . three-web seat, for maximum fluid passage without increase in fluid velocity . . . and the specially designed compound 808 insert, which outlasts other inserts on the market today!



Subsidiary of AMF AMERICAN MACHINE & FOUNDRY COMPANY, New York

WE TIED A KNOT IN THE "TIGER TAIL"

so it won't slip through your glove. You'll never know what "spinning" really means until you grab hold of that Tiger Tail. Proof-tested links "spin 'er up fast" and they last and last for more round trips. Try it yourself—pick up a genuine Web Wilson TIGER TAIL Spinning Chain, in the yellow and black box, at your supply store.

WEB WILSON

Oil Tools INC. FIELD PROVEN

LOS ANGELES • DALLAS • NEW YORK

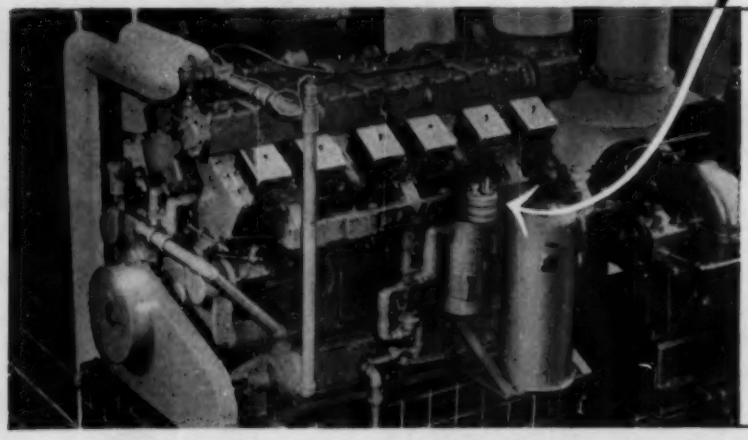
MARVEL INVERSE OILER—
Vital Part of World's Finest Engines

Engine manufacturers think so highly of the Marvel Inverse Oiler they have incorporated it as a vital unit in their engines' lubrication systems.

They have found that engines, equipped with Marvel Inverse Oilers, can be depended upon to give quick acceleration to save trip time . . . keep operating costs to a minimum . . . guarantee hours of continuous performance . . . keep "down-time" low by extending periods between overhauls.

The famous Climax Engines, one of which is pictured below, is an example. A truly fine performer, it is equipped with a Marvel Inverse Oiler for Marvel Mystery Oil—finest performing lubricant of all.

The Marvel Inverse Oiler feeds Marvel Mystery Oil in exact proportion to engine speed and load . . . properly lubricating valves and guides, preventing wear and sticking. Keeps upper piston rings free in their grooves . . . retards ring flutter . . . and cushions ring pounding which can result in ring breakages. Remember, it is the *oil* which must do these things and only Marvel Mystery Oil is blended for this purpose and for this oiler.



The Marvel Inverse Oiler

is an integral part of the Climax 12 cylinder, 171 H.P., 600 RPM GAS ENGINE. Operating off the intake manifold, this completely automatic Oiler feeds Marvel Mystery Oil exactly in proportion to engine loads . . . gives direct protection to the all-important upper cylinder areas.

This Chart shows the proper setting for constant load engines ▶

BRAKE H. P. AT BELT	NAT. GAS CU. FT. PER HOUR	BUTANE GALLONS PER HOUR	GASOLINE GALLONS PER HOUR	M. M. OIL DROPS PER MIN.	M. M. OIL HOURS PER QUART
10	115.	1.07	1.12	4	228
15	172.5	1.60	1.68	6	152
20	230.	2.14	2.24	8	114
25	287.5	2.67	2.80	10	91
30	345.	3.21	3.36	12	76
35	402.5	3.74	3.92	14	65
40	460.	4.28	4.48	16	57
45	517.5	4.81	5.04	18	50
50	575.	5.35	5.60	20	45
60	690.	6.42	6.72	24	38
70	805.	7.49	7.84	28	32
80	920.	8.56	8.96	32	28
90	1035.	9.63	10.08	36	25
100	1150.	10.70	11.20	40	22
120	1380.	12.84	13.44	48	19
140	1610.	14.98	15.68	56	17
160	1840.	17.12	17.92	64	14
180	2070.	19.26	20.16	72	12
200	2300.	21.40	22.40	80	11
225	2587.5	24.00	25.20	90	10
250	2875.	26.75	28.00	100	9
275	3162.5	29.42	31.10	110	8
300	3450.	32.10	33.60	120	7

Chart shows total oil consumption ◀

EXAMPLE:—If you use 805 cu. ft. of dry gas, 7.49 gallons of butane or 7.84 gallons of gasoline, your H.P. is about 70, so adjust oiler to feed 28 drops per minute. You will then receive about 32 hours per quart of MARVEL MYSTERY OIL.

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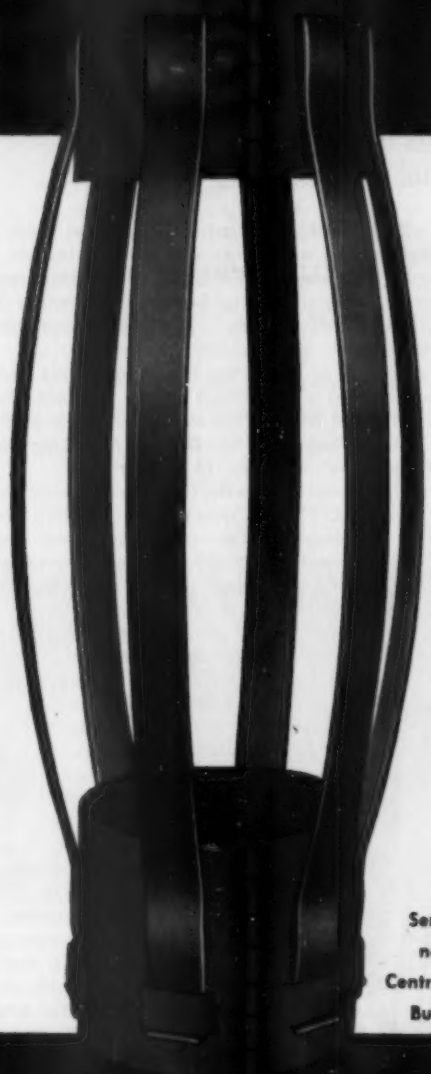

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NEW	smaller diameter allows easy passage through spider and rotary table — eliminates banding and cutting
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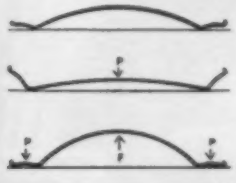

1. Spring used in a Red Top Centralizer at rest.
2. If pressure (P) is applied the ends of the spring will rise.
3. Conversely, if pressure (P) is applied to the ends, the spring is "pre-stressed" and exerts force (F) outward.

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The operator of this shallow California well wanted to test a 35 foot upper zone that lay behind two strings of cemented casing. Interval to be perforated was from 1800' to 1835'. Casing at this point was 8¾" O.D. 36 lb. cemented in 11¾" O.D. 54 lb. which was cemented in 15" open hole—a minimum of 7.175" of steel and cement had to be perforated if the 15" hole was exactly to gauge.

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128 improved ½" Ogival Bullets were fired in the 35 foot zone by 4¾" O.D. McCullough M-3 Bullet Guns. Total time on the job was only one hour and 45 minutes. Adequate penetration was accomplished without question, since 30 barrels of oil per day are being produced from the new zone—a good well for the field.

M-3 Bullet Perforators are the original solid steel bodied bullet guns, pioneered and developed by McCullough Tool Company. Size for size they are stronger than any other bullet gun available—have greater firing power—give you deeper penetration.

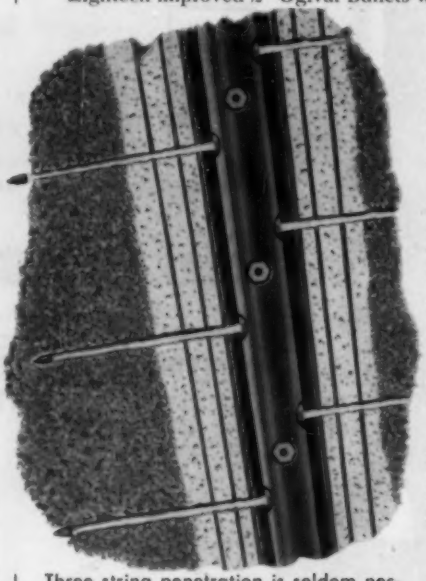
Hardest Shooting M-3's Penetrate Three Strings For a Good Well

Powerful M-3 Guns, Firing Improved Ogival Bullets, Penetrate Multiple String of 7", 5½" and 4½" O. D. Pipe for Good Production.

Few perforating companies will attempt three string penetration with a bullet gun with any reasonable assurance of success. An exception to the rule is McCullough Tool Company. Recently, powerful M-3 Bullet Perforators were used to perforate a newly discovered thin zone lying behind three strings of pipe. Another service company, first offered the job, would not attempt such penetration.

This was a shallow South Texas well in which the lower productive zone proved unprofitable. The operator decided to come back up the hole and perforate a promising three foot zone at 2134 feet. At this interval 7" O.D. 24 lb. casing had been cemented in open hole. A string of 5½" O.D. 14 lb. casing had been cemented in the 7" and inside the 5½" was a 4½" O.D. liner.

Eighteen improved ½" Ogival Bullets were fired in the three foot zone by 3½" O.D. McCullough M-3 Bullet Perforators. Two perforating runs were made with a bailer run in between. Total time on the job, including the bailer run was two hours. Result: A fine well for the field and another satisfied McCullough customer.



Deep penetration is the most important single benefit to be gained from perforating. M-3 Bullet Guns have the power to penetrate one, two, or even three strings of tough casing (as in the above job); through cement sheaths and deep into the formation—far enough out into the pay zone to get the results you want—peak production, more oil!

McCullough M-3 Bullet Perforators always give you deepest penetration. The proof: In competitive tests, McCullough M-3's consistently outshoot, outperform all other bullet guns.

Three string penetration is seldom necessary, yet it is assuring to know that McCullough M-3 Bullet Guns have the firing power needed to accomplish such a job. Even more assuring is the knowledge that, for the usual single string perforating, M-3 Guns will give you depth of penetration that cannot be equalled by any other bullet perforator.

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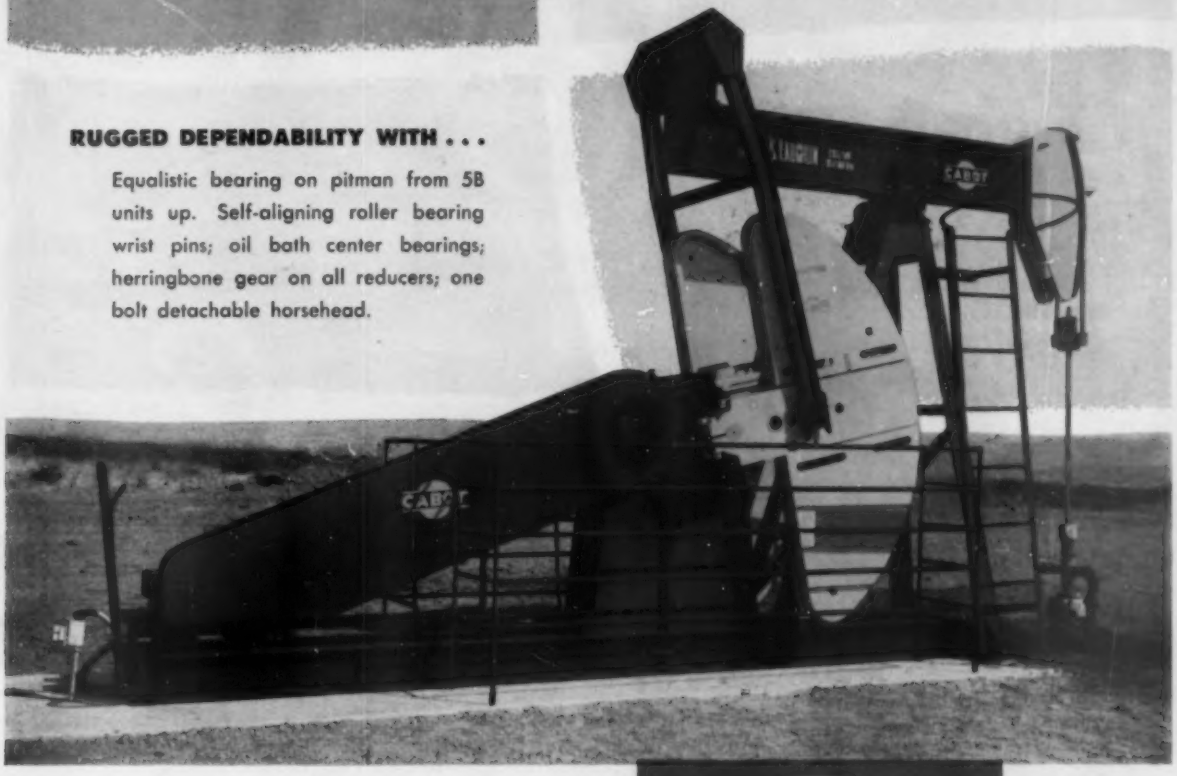

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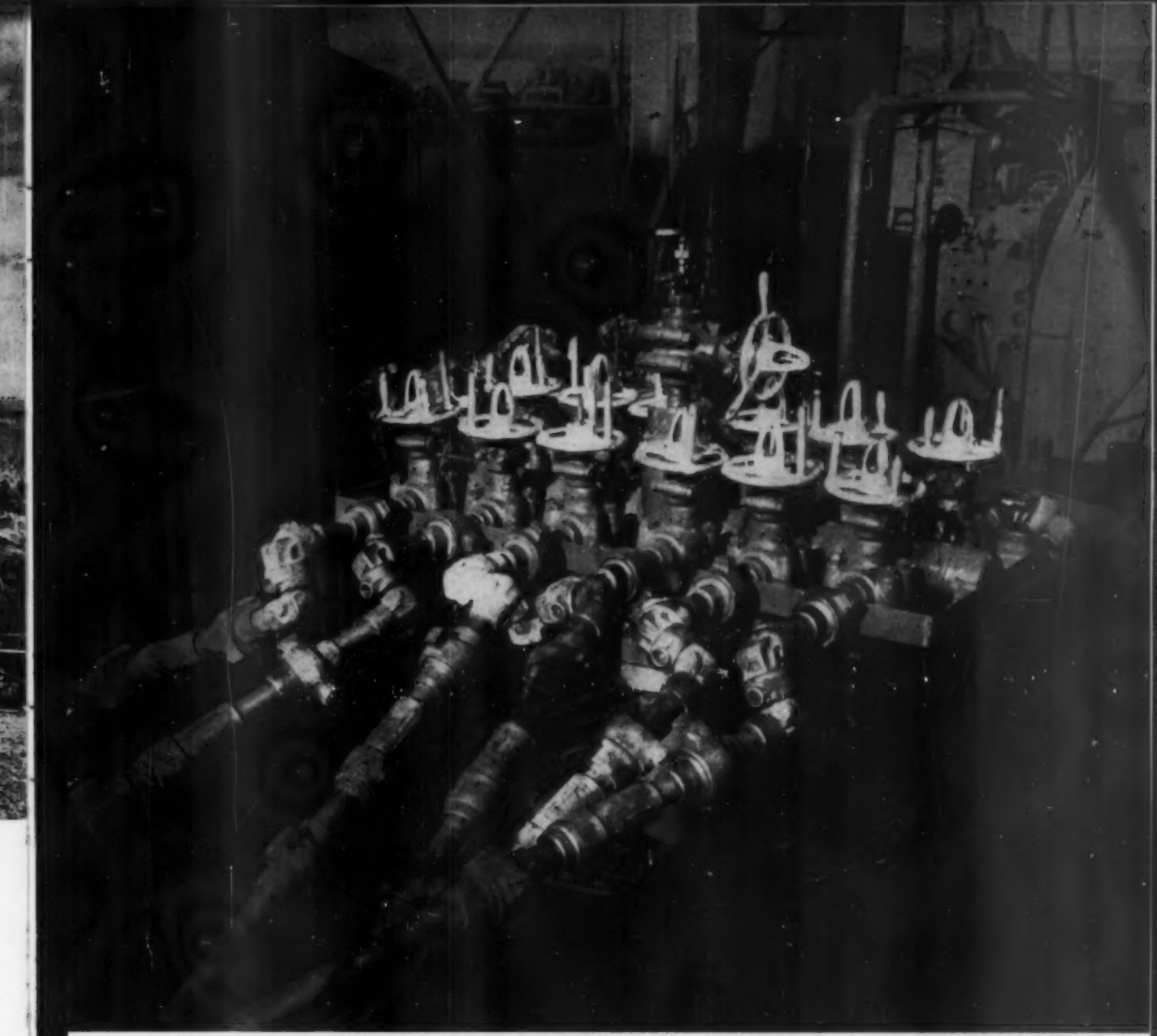

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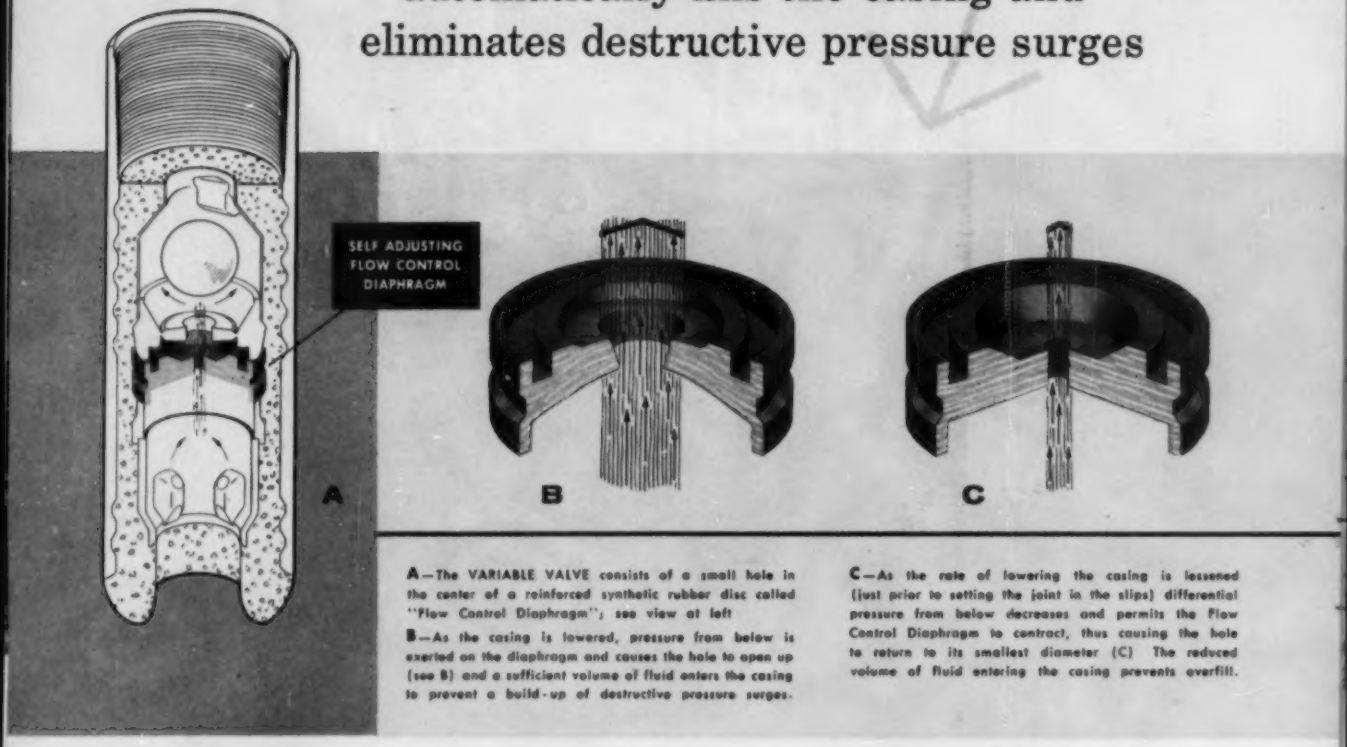
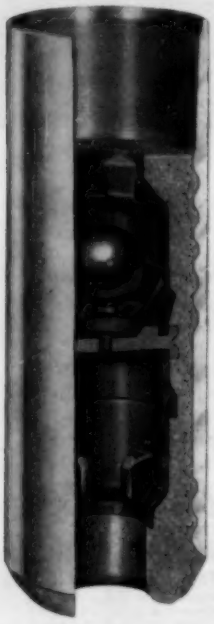
how the variable valve in FLEXIFLOW Shoes and Collars automatically fills the casing and eliminates destructive pressure surges



A—The VARIABLE VALVE consists of a small hole in the center of a reinforced synthetic rubber disc called "Flow Control Diaphragm"; see view at left

B—As the casing is lowered, pressure from below is exerted on the diaphragm and causes the hole to open up (see B) and a sufficient volume of fluid enters the casing to prevent a build-up of destructive pressure surges.

C—As the rate of lowering the casing is lessened (just prior to setting the joint in the slips) differential pressure from below decreases and permits the Flow Control Diaphragm to contract, thus causing the hole to return to its smallest diameter (C) The reduced volume of fluid entering the casing prevents overfill.



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When casing equipped with FLEXIFLOW Shoes or Collars is lowered in the well, increase in pressure from below causes the variable valve to open up wider to relieve pressure from below by permitting a large volume of fluid to enter the casing. When downward movement of the casing is slowed down, pressure from below is reduced and the hole in the diaphragm contracts to restrict the fluid entry and prevent overfilling. This action of the variable valve in opening wider and closing down, synchronizes the rate of fill of the casing with the rate of lowering the casing, *and in so doing provides maximum relief from pressure surges.*

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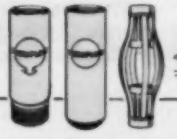

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An Engineer's Look at . . .

Turbine Drilling

Soon to be introduced in the U. S., method is now used in 83 per cent of wells drilled in Russia. Here's the story of the turbodrill, how it works, and some performance data.

James A. LeVelle

IS the turbodrill the next major advancement in U. S. drilling? Recent developments indicate that the turbodrill, greatly improved over the experimental models used in this country 6 years ago, will again be introduced to the drilling industry. If tests provide only a part of the success reported in Europe, its commercial use is not far away. Advanced techniques have been developed and are being applied to reduce well costs in other countries. Whether the turbodrill will improve drilling economics in this country depends upon its adaptability to U. S. drilling requirements. Forthcoming field tests will provide the answer.

Long considered superior theoretically to the conventional rotary, U. S. development of the turbodrill has been slow due to more immediate needs and progress in other avenues of endeavor. Attempts to develop commercial units stalled in 1950 when tests in the field with experimental designs failed to yield conclusive results. European industry, faced with considerably different drilling and economic problems, has succeeded in perfecting the turbodrill in recent years and is deriving economic benefits in many areas. Units are being commercially produced in France and Russia.

Use of the turbodrill in the Western World is limited at this time, but there are indications that this technique will be extended into many areas.

In Russia, the turbodrill has been used commercially about 10 years with the result that the number of wells drilled by this method today exceeds both cable tool and rotary. Reports from Russian sources indicate that 83 per cent of the wells drilled in 1955 were completed by the turbodrill method. This is nearly 50 times the use reported in 1946.

DEVELOPMENT OF THE TURBODRILL

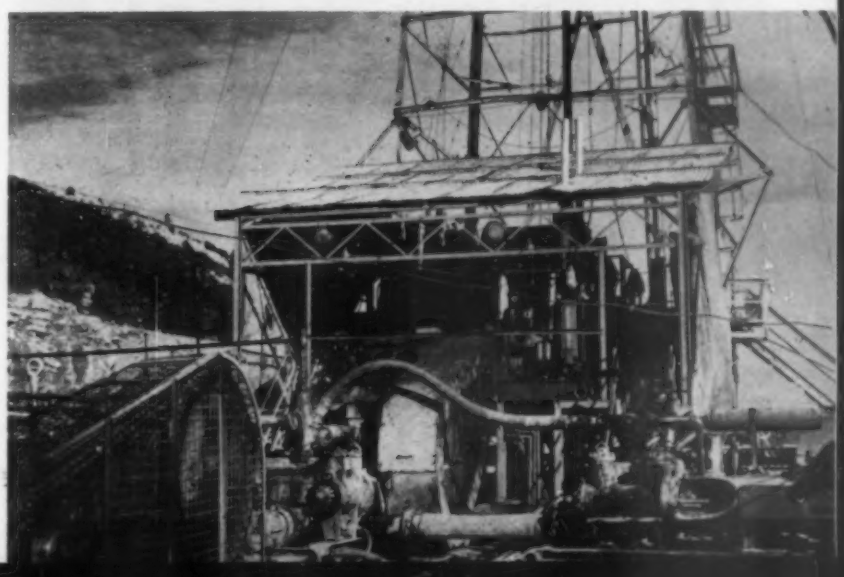
Thought to be new and revolutionary, the concept of a turbine drilling unit dates back to 1873. In this year, Christopher G. Cross of Chicago, Illinois, was granted patent No. 142992, entitled "Improvements in Drill for Boring Artesian Wells." This patent described a single-stage hydraulic turbine for use in driving a diamond drill bit. Also, in 1884, the noted George Westinghouse, Jr. secured patents that described many of the essential elements of turbodrilling. However, he proposed the use of a positive displacement motor instead of the turbine.

While ideas were recorded before the turn of the century, steps were taken to develop a mud turbine only 30 years ago. In 1924, C. C. Sharpenberg secured patents for a multiple-stage turbine remarkably similar to the designs used at this time. This unit was built by the Standard Oil Company of California and was tested at Elk Hills, California, in 1926. About the same time Russian M. A. Kapelyushnikov developed a device in which a single-stage turbine was utilized to drive the bit through a planetary gear system. This unit was built and tested in Russia in 1925. It is interesting to note that Kapelyushnikov demonstrated his unit in this country in 1930 in an Oklahoma well. While approaching the design from different directions, results obtained with these early units were sufficiently attractive to warrant further development.

U. S. Development Centered Around Sharpenberg Turbine

Impressed by the mechanical possibilities demonstrated by the early Sharpenberg turbine, efforts in this

Layout of mud pumps on rig using the turbine drilling method in the southern part of France. Each pump is equipped with pulsation dampeners to reduce pressure fluctuations.



country were primarily directed toward the perfection of this unit. In the early designs, mechanical bearings were used to carry both the radial and thrust loads of the turbine. Seals designed to exclude fluid from the bearings invariably leaked and cut out as a result of the abrasive action of the drilling fluid. In 1935, the Standard Oil Company of California and the A. O. Smith Corporation initiated a joint development program and extensive testing and developmental work was carried on by these companies during the years 1935 to 1941 and 1949 to 1950. Main progress was made from 1935 to 1941 during which time success was obtained in developing rubber journal bearings to replace the mechanical radial bearing. Also, progress was made toward the development of adequate thrust bearings. Still plagued with bearing difficulties, the project was abandoned in 1950 after units failed to show any appreciable improvement over rotary methods.

Also of note is the Edco turbodrill which was built in 1948 and similarly abandoned in 1950.

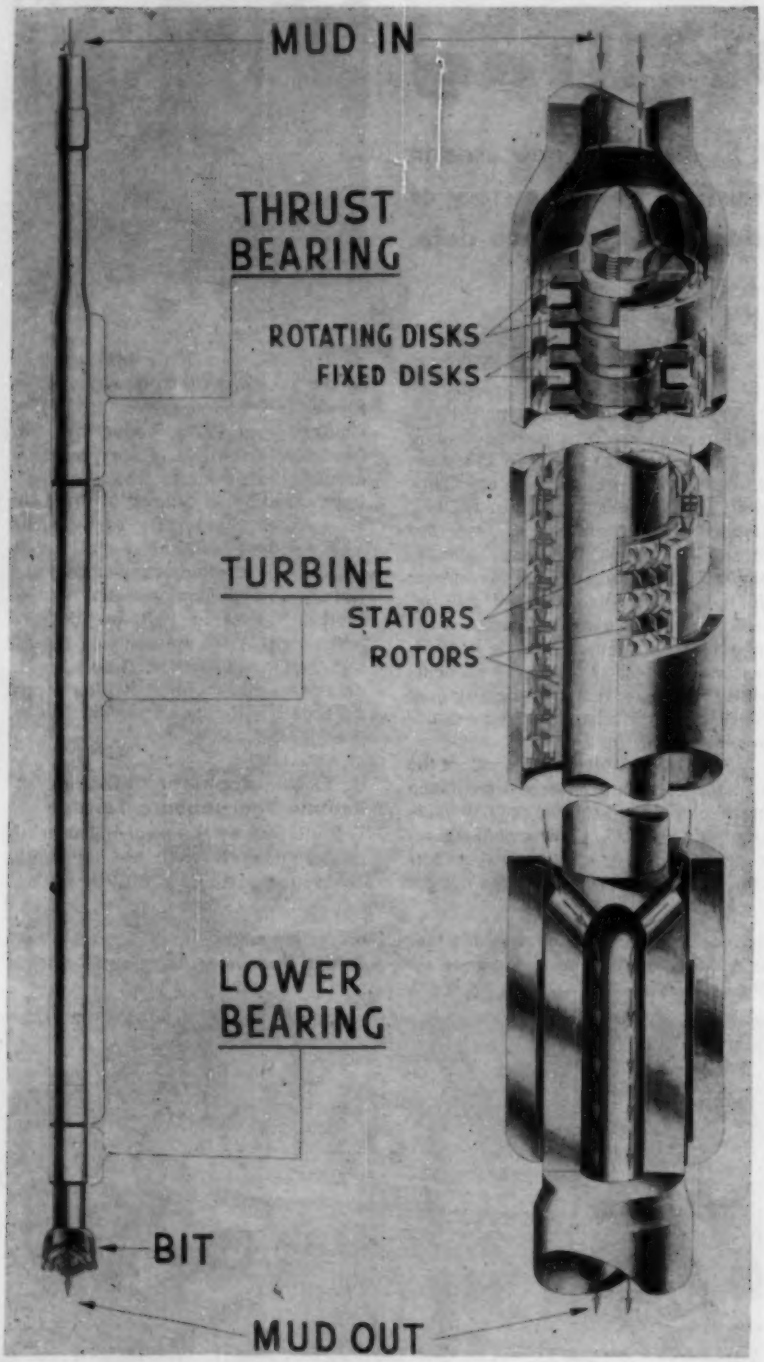


FIG. 1. Major components of the turbodrill. Mud flow through the turbodrill system is downward through the bearing house, into the section turbine and out through the bit.

Foreign Developments

The list of patents and experiments in other countries include work in England, The Netherlands, Germany, Yugoslavia, France, and Russia. With the exception of Russia, the contributions made to the development of turbine drilling is not known at this time. Evolution of the Russian drill can be traced from its beginning in 1925 to the commercial unit in use today.

The Kapelvushnikov single-stage turbine tested in 1925 utilized ball bearings and a planetary gear system between the turbine and bit. Severe erosion was encountered due to high mud velocities. A 6 to 8-stage unit was developed from 1933 to 34 to reduce the turbine speeds and consequently mud velocities. As a result of major difficulties encountered in the gear box, this component was eliminated and the turbine was directly coupled to the bit. This design was introduced in 1934. Up to this point, units were equipped with ball type radial and thrust bearings. From 1938 to 1939, units were modified to include rubber radial bearings and in 1949, Russian designers began the use of an all-rubber bearing model. Main advantage of this design was that the drilling fluids act as the lubricant. The 1949 design, with modifications, is being used in Russian drilling at this time.

Status of the Turbodrill Today

In a sense, the turbodrill has come of age. Technically the turbine has evolved to its simplest form and reports indicate that major obstacles have been overcome. It is known that durable mud turbines can be built and provided with an acceptable operating life.

With 10 years of manufacturing experience and industrial use, there is little doubt that Russia will continue to improve the turbine as well as other equipment required in its application. With 83 per cent of wells drilled with this equipment, it must be assumed that units are satisfactory for Russian drilling requirements.

The French company, Ets. Neyrpic, has completed development of a design tailored to Western European drilling needs and is now manufacturing units for industrial use. The Neyrpic turbine is very similar to Russian

designs and is being utilized in much the same manner. It has been announced that the Neyrpic turbine also will be manufactured in Germany.

In this country, an extensive development program has been undertaken by Dresser Industries, Inc., directed toward the introduction of equipment suited to U. S. operations.

Economics of the Turbodrill

Economics of the turbodrill rest primarily upon its ability to provide increased drilling rates and reduce drill pipe costs. Reduction in wear on the drill pipe and lighter service imposed reduces replacement requirements and permits the use of lighter drilling strings. While increased pump capacity is required by the turbodrill, savings can be made through lower costs for drill pipe and other rig components.

Economic studies prepared by the Standard Oil Company of California in 1941 indicated that savings of $6000 to $10,000 per well could be made through the use of the turbodrill. Included in this savings is the depreciation on rig equipment which was estimated to cost $40,000 less than the rotary rig, and savings in the replacement of drill pipe. Based on records from 1936 to 1940, it was found that drill pipe replacements constituted 43 per cent of all replacement expense. In this company's operations, drill pipe cost was $300,400 per year while $397,000 per year was spent for all other rig equipment replacements. Since the drill pipe does not turn and is subjected to light duty in the turbine method, replacement of drill pipe due to wear is considered negligible. There is evidence that the drill pipe replacement percentage indicated is reasonably accurate today. Costs at this time are approximately 2¼ times the corresponding cost at the time this study was made.

In 1950 economic estimates based on the performance of the experimental Edco turbodrill indicated that well savings of 15 to 25 per cent could be made in South Louisiana wells in the 10,000-ft depth range.

The economics of turbodrill operations must be based upon competitive performance. At this time, sufficient data are not available to permit a comparative evaluation based upon modern rotary practice and the modern turbodrill.

How the Turbodrill Works

The technique of conventional rotary drilling embodies the transmission of power to the bit by means of the drill pipe. Acting as a long, limber power shaft, the drill stem is subjected to vibrations, wear, and dynamic as well as static torque. Losses in transmitting power result from the viscosity of the drilling fluid and from friction between the pipe and hole. Speed is limited due to whipping of the drill string and torque is limited to the dynamic torsional strength of the pipe.

Some authorities have estimated that less than 10 per cent of the power delivered at the rotary actually reaches the bit. Since the losses are dependent upon depth, hole size, density of the mud, weight on the bit, etc., it is felt that this estimate is probably low in wells of less than 8000-ft depth. On the other hand, it appears high for wells over 10,000 ft deep. A number of experiments indicate that under present rotary practices, only 10 to 25 hp is actually utilized in drilling in deep wells. The remaining power is consumed in transmission.

In the turbodrill, rotating power is generated just above the bit with the result that higher speeds may be used. Since the drilling string does not rotate, torque loads are basically static and the factor of wear is virtually eliminated. Losses in transmitting power occur principally in the form of pressure drop in the drill pipe which can be adequately controlled through proper size selection. More power can be applied to the bit with greater efficiency.

For example, consider a turbine and hydraulic system to have an efficiency of 60 per cent, which is powered by a mud pump having an efficiency of 70 per cent. If 300 hp is applied to this pump, the power available at the bit is 126 hp. Based upon estimates that 10 per cent of the power reaches the bit in conventional rotary systems, 300 hp applied to the rotary table will provide about 30 hp to the bit. Assuming that the bit used can apply this power efficiently, it appears that the turbodrill would penetrate the formation at least 4.2 times faster than the conventional rotary.

Description of the Drill

The turbodrill is an extension of the rotary method and is simple in its construction. It consists of only four basic components which include the upper bearings, the turbine, lower bearings, and the bit. A schematic drawing of the turbodrill designs presently in use is provided in Fig. 1.

Upper bearing. The upper bearing acts both as a thrust bearing and as a radial bearing for the turbine shaft. This bearing consists of a number of rubber faced disk type surfaces similar in design to conventional journal type thrust bearings. Drilling fluid provides lubrication for the bearings and disipates heat generated during operations. Units are designed to withstand both the weight placed on the bit in drilling and the downward thrust reaction of the turbine rotor.

The turbine. The turbine section consists of matching numbers of rotors and stators of which each pair constitutes one stage. Present models have 100 or more stages in order to provide sufficient torque at reasonably low turbine speeds. Several intermediate radial bearings are used within the turbine to prevent whipping and maintain shaft alignment. The blade widths are short relative to the overall diameter and have contours similar to the blading used in steam turbines. A typical turbine stage and diagram of fluid flow through the blading is shown in Fig. 2.

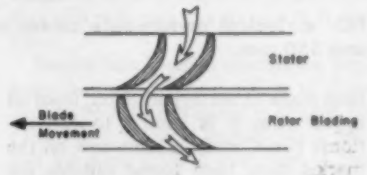



FIG. 2. Typical cross section of turbine blading showing the flow of fluid through one stage of the unit.

Basic relations that govern the design of turbine blading are the same as steam turbines or other hydraulic turbine devices.

Basic relations such as nozzle angle, blade angle, flow velocities and rate are altered to provide turbines capable of operating within the speed ranges desired. In practice, turbodrills are designed to provide an equal pressure drop across each stage. For instance, a turbine designed for a pressure drop of 6 psi per stage would have a total pressure drop of 600 psi in a 100-stage unit.

Lower bearing. The lower bearing section of the turbodrill acts as the lower radial bearing and as a seal between the stationary and rotating members. The unit consisted of a rubber faced radial bearing that also provides some sealing characteristics. The seal is designed to leak slightly since it is desirable to have some flow through the bearing for lubrication and to disipate heat.

The bit. While much discussion has

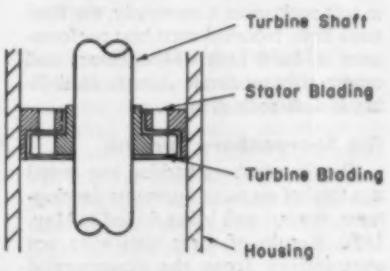


FIG. 3. Design of single-stage section in turbodrill.

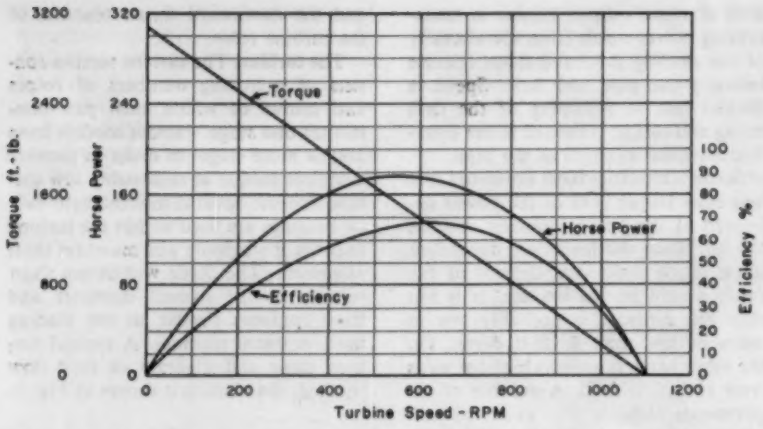


FIG. 4. Typical performance curves for a 10-in. turbodrill rated at 700 gpm and 550 rpm.

been made of the turbodrill bit, from all appearances it is similar to conventional bits. Certain models now on the market have been found suitable for turbodrilling techniques.

Characteristic of the Turbine

As is the characteristic of the turbine, peak efficiency occurs at approximately one half of the runaway speed, as shown in Fig. 4. In this typical performance curve shown, maximum power is developed at 550 rpm and maximum efficiency occurs at a slightly higher speed. In drilling, the turbine would be operated between about 450 and 700 rpm in order to obtain maximum power. Characteristics of units can be altered appreciably by blade design to provide either flatter or steeper curves as the intended service should dictate. This is normally accomplished with some loss in turbine efficiency, however. Performance for any given turbine normally is based upon the optimum or design rate of flow.

Performance of Turbodrill

Paralleling the history of development of the turbodrill, performance obtained in drilling operations both here and abroad is of considerable interest. The most outstanding difference in application has been the type of formation to which the turbodrill has been applied. In the U. S., tests were made in soft rock areas. Conversely, the Russians have reported their best performance in hard rock drilling areas and report only moderate success in drilling in soft rock areas.

The Sharpenberg Turbine

The Sharpenberg turbine was tested in a total of six wells during its development, the last well being drilled in May, 1950. Results of these tests were not outstanding from the commercial standpoint since the tests were conducted for research purposes only and were aimed primarily at proving out design features of the drill. No effort was made to secure maximum penetration.

The last test was made in May, 1950, on Standard Oil Company of California's No. 367-27-F well in California with a 9-in. 30-stage turbine. The hole was drilled to 3012 ft with a total drilling time on bottom of approximately 59 hr. Average rate was 51 ft per hr that compared most favorably with prewar drilling rates, but was less than penetration rates obtained by rotaries in the area in 1950.

Results of dynamometer tests made on the 9-in. turbodrill are provided in Table 1 and are the maximum values obtained for each flow rate. A mud weight of approximately 12 lb per gal was used.

Table 1.—Performance of the 9-in. Turbine in Laboratory Dynamometer Tests
Data is based upon a 30-stage turbine*

GPM	300	400	500	550
RPM	400	450	600	750
Torque lb-ft	174	411	594	648
Horsepower	13.2	32.7	69.0	92.7
Press. Drop	156	294	474	576
Eff. %	47	48	50	50.5

*Compiled from data presented in the paper, "Progress of Turbodrill Development in California," by W. R. Postlewaite.

In the test conducted on well 367-27-F, the flow rate was increased to 875 gpm and the turbine operated at 1200 rpm with pump pressures of around 1100 psi. With this circulation rate, it was estimated that the turbine developed about 190 hp. With the unit thus overloaded, considerable difficulty was encountered due to thrust bearing breakage.

The Edco Drill

Field testing of the Edco (Engineering Development Company) turbodrill was carried out from 1948 to 1950. In this period, runs were made in five wells in the South Arkansas and South Louisiana areas. Test drilling runs were made in conjunction with regular drilling operations and included drilling at depths up to 5400 ft. Drilling was in relatively soft, lightly consolidated formations.

The Edco turbodrill was 30 ft long, weighed 8000 lb and had a design fluid rate of 880 gpm. In tests, the turbodrill was run with conventional rigs and as a result, the circulation rates available were somewhat less than desired. Flow rates ran between 450 and 600 gpm. The average bit loading was reported to be 3000 lb. Penetration rates were reported to be approximately the same as those obtained with conventional rotary rigs in the area. Below are average penetration rates reported for four out of the five tests:

Footage Drilled	Hole Size in Inches	Penetration Rate Ft/hr
30	13	720
120	13	610
1300	13	200
850	13¾	148
1100	12¼	120
2000	13	120
350	12¼	75

Bit life obtained in several tests showed some improvement over that obtained with rotary rigs in the area. This was considered in part due to the light drilling loads used, however.

The French Turbodrill

To date, only one report of French turbodrilling operations has been received. This was a test conducted in the St. Bauzille De Montmel area to compare the penetration rate offered by turbodrills with that of conventional drilling methods. The well was drilled from 868 to 2139 ft alternately using turbine and conventional drilling methods. It is reported that where possible, the best technique offered by the two methods was used and similar zones were drilled. Comparative results obtained are shown in Table 2.

Due to the coring operations required, it was not possible to obtain a comparison through all formations drilled. A considerable amount of drilling consisted of coring and redrilling following coring operations. The drilled hole size was 12¼ in. and the core drill used was 6¼ in.

The report indicated that a considerable improvement in both penetration rate and bit life was obtained. By comparison of bit life in a number of runs, the turbodrill showed an increase in bit life up to 33 per cent. As shown by the data in Table 2, the penetration rate was considerably greater than that shown for the rotary drill. Since only one test is shown, data are not considered conclusive.

However, new data should be available in the future since several companies in Europe are now testing or are

TABLE 2. Comparison and Drilling Performance, St. Bauzille De Montmel Area, 12¼-in. Hole

Formation	Type Drilling	Depths	Weight on Bit	Ft/Hr Penetration Rate
Marly	Rotary	868-1048	11,000	6.5
Limestone	Turbodrill	1070-1220	17,600	21.7
Siliceous Limestone	Turbodrill	2090-2097	33,000	26.2
	Rotary	2097-2115	8,800	.9
	Turbodrill	2118-2127	39,600	12.1
	Rotary	2127-2139	8,800	.9

TABLE 3. Design Characteristics of Latest Russian Production Model Turbodrills

T. D. Size	Design Flow Rate Q=gpm	Design Speed rpm	Torque lb/ft	Pressure Drop Thru Turbine psi	H P Design Conditions	Length	Approx. Wt.	Drill Pipe Size
Mud — Sp. Gr. = 1.2								
10"	714	550	1660	600	175	29' 3"	5210	6⅝
	950	730	2480	1195	420			
8"	600	615	1048	655	125	29' 3"	3530	5½
	760	775	1660	1040	250			
6⅝"	348	580	347	456	39	27'11"	2350	4½
	475	795	636	854	98			
Water								
10"	790	610	1700	683	200			
	1080	830	3145	1268	505			
8"	634	645	976	598	120			
	870	890	1844	1139	315			
6⅝"	396	660	362	498	47			
	554	925	723	968	120			

80 to 100 stages for standard T.D. shown above. All above sizes now produced as sectional T. D.; which eventually doubles number of stages, length, pressure drop and hp output.

TABLE 4. Operational Data from Drilling of the Russian Well, Devonian Well No. 879 Well Was Drilled With Mud Using a 10-in. Turbodrill

Formation	Intervals Drilled	Drilling Conditions: Circulation Rate gpm	Load on Bit (1000 lb)	Circulation Pressure psi	Bit Performance: Bit Runs	Average Footage per Bit	Penetrations Rate ft/hr
Kagan and Ufa	0- 735	870	19.8	850	1	735	105
Artinskian	735-1160	870	22.30.8	850	3	142	88.5
Upper-Carboniferous	1160-1905	870	35.2-37.5	850	3	141	115.5
Mischovian	1905-2020	870	39.6-48.4	995	7	61.6	49.2
Podolian	2020-2260	870	39.6-48.4	995	5	47.2	44.3
Kashir	2260-2490	870	33 -35.2	995	4	57.4	65.6
Vizeiskii	2490-2700	870	35.2-37.4	995	2	106	72.2
Namur	2700-2980	870	38.4	1140	4	69.5	53.8
Serpukhovian	2980-3034	870	33 -39.6	1140	4	114.2	61
Tula	3034-3540	870	35	1140	1	98.5	78.7
Carboniferous	3540-3630	870	30.8	1140	1	98.5	44.6
Tournaisian	3630-3810	870	33 -37.4	1140	1	174	43.9
Upper-Famennian	3810-4275	870	44 -50.6	1280	4	116.5	48.8
Lower-Famennian	4275-4940	870	44 -50.6	1280	6	112	46.2
Askin	4940-5100	795	33 -36.2	1420	4	41	4.1
Naddomanikov	5100-5360	795	44 -50.6	1420	7	35.4	20.3
Shugarov	5360-5430	795	50.6	1560	1	72.2	26.2
Kynovian	5430-5490	795	44 -46.2	1560	1	52.5	23
Pashiiskii	5490-5530	795	50.6-55	1560	1	52.5	26.2
Givetian	5530-5620	795	52.8	1560	2	42.6	31
				Total Bits Used 62			

planning to make tests in the near future.

Russian Turbodrill Performance

The most extensive experience in turbodrilling today is that of the Russians. Having been used in the field for about 10 years, tools and techniques are now available to utilize the advantages of the turbodrill.

Information concerning methods used and overall performance is limited, however, due to the small number of reports received in this country. Reports indicate that they have been successful in increasing penetration rates over the Russian rotary and that equipment available is adequate for their operations. In view of the large percentage of wells being drilled in Russia by this method, there is little doubt that it has been found more applicable than the rotary rig.

Turbodrills are being built by the Russians in sizes from 5 in. up to 10 in. in diameter. According to reports, the 8 and 10 in. units are most commonly used, while smaller units in the 6⅝-in. and 5-in. sizes are basically used in exploratory drilling. Dimensions and the results of dynamometer tests on 10, 8, and 6⅝-in. commercial units are provided in Table 3. Where additional drilling horsepower is required while maintaining established circulation rates, units are compounded. For all practical purposes, the length, pressure drop, and horsepower output are double that shown in Table 3. Efficiency of Russian units on dynamometer test have been found to be as high as 80 per cent. The efficiency of field turbodrills is around 70 to 75 per cent, however.

Russian performance reported. Data concerning the performance obtained by drillers in Russia were presented before the World Petroleum Conference in Rome, Italy, in 1955. As an example of the improved drilling rates obtained with the turbodrill, data were presented regarding the Russian Tuymazy district which is described as a hard rock area. In wells drilled to 5900 ft, an average penetration of 6.5 ft per hour was reported for rotary operations. In this same area average drilling rates of 49 to 59 ft per hour were obtained with the turbodrill.

It also was reported that the simple turbine (100 stages) had proved ineffective in soft and medium-hard formations. However, suitable results were obtained with sectional drill or compounded turbine units. As many as three sections had been used, providing up to 240 stages. Using sectional units, a two-fold increase in penetration rate over the rotary was reported in the Buzovny area where several wells were drilled to 6500 ft. An average penetration rate reported was 80 to 120 ft per hour.

Insight into Russian operations. Perhaps the most promising view of Russian turbodrill operations is offered by recent data released concerning a record breaking drilling operation in the Second Baku area. The operations described were encountered in drilling Devonian well No. 879 to 5630 ft in a record 15½ days. Drilling data on this well are provided in Table 4.

Interestingly enough, penetration rates obtained by the driller were not considered to be on a par with rates normally obtained in the area. The record drilling time was attributed to reduced trip time and a reduction in cementing time on surface casing. The size hole drilled was 17¾ in. to 735 ft where 12-in. casing was set and 11¾-in. below the casing shoe to total depth. The actual total bit time on bottom was reported to be 110.25 hr.

The overall average penetration rate obtained was 50.8 ft per hour, which was described as being about 30 to 40 per cent lower than has been encountered in the area. The reason given was that adequate pump capacities were not available. Circulation rates were 795 to 870 gpm. Normal practice in the area is to use rates of 1000 to 1100 gpm. The rig was described as having two mud pumps, a rotary table, and as being newly equipped with power tongs and slips. Apparently, the drawworks and other equipment were conventional for Russian drilling operations.

Application of the Turbodrill

In considering the turbodrill, of considerable interest is the technique used in drilling. In early tests, the object was to develop the tool itself. Little effort was made to evaluate the best method of using the characteristics of the turbine. In tests conducted in the U. S., methods were based entirely upon rotary drilling facilities.

It appears that Russian engineers

were faced with the problem of using the tool in the field during various stages of development. Methods were developed that were both beneficial to the life of the tool as well as to obtain adequate drilling rates. A study of the European practice yields some insight into the techniques required to obtain the best operation of the turbine type unit.

Penetration rates. It is well known that increased penetration can be obtained by increasing bit speeds and by increasing bit weight. While the limits to which increasing speed yields greater penetration rates is not known, the limits of weight on the bit have been established for many formations and bit designs.

The speed range of any given turbine is somewhat limited and as a result, loading becomes one of the major factors involved in its optimum use. Through the selection of the proper turbine and bit loads, optimum drilling rates may be obtained.

The hydraulic horsepower that must be supplied to the turbine by pumps is approximately the same at no load as it is at maximum output. In order to benefit from this power, the operating speed must be maintained near the optimum operating speed. Speed of the turbine is the main criterion considered during drilling operations and is evaluated in selecting the turbine, bit, and the circulation rates to be used. If the turbine speed cannot be controlled by adjusting bit weight, either the bit is changed or circulation rates are lowered or raised as the situation dictates.

Reduction of flow rate reduces power to the bit, the operating speed and also the pressure drop through the turbine. The variation in power and other factors with flow rate may be estimated by the following:
Where Q is the rate of flow through the turbine,

Operating speed	αQ
Torque	αQ^2
Power	αQ^3
Pressure Drop	αQ^2

Since power is proportional to the cube of the flow rate, it is preferable to use higher flow rates to provide greater power at the bit.

Bit loads. The load placed on the bit in European turbodrilling has two basic functions: (1) To obtain maximum penetration rates, and (2) partially balance the downward thrust of the turbine. In practice, reducing the load on the turbine bearings greatly reduces maintenance on the turbines. The approximate hydraulic thrust produced is given by the following equation:

$$\text{Thrust} = \frac{\pi}{4} P_t d^2$$

Where P_t = pressure drop across the turbine
d = average diameter of the turbine blading

Hydraulic thrust of the simple 10-in. Russian turbine varies between 26,000 and 40,000 lb and that of the sectional turbine ranges up to 55,000 lb. These values are in the range of weights placed on bits in this country in hard rock areas.

Pressure losses. Since power available is in the form of hydraulic horsepower, power is represented by both pressure and volume. In the design and application of the turbodrill, the circulation rate is normally fixed by either the pump capacity or the optimum turbine rate. Considerable attention is paid to the pressure losses in the system. The pressure drop through the system includes circulation losses, pressure drop across the turbine, and pressure drop at the bit. The hydraulic horsepower required is as follows:

$$HP = \frac{(P \text{ loss} + P_t + P_b \text{ GPM}}{1714}$$

where
P loss = flow losses (psi) in surface equipment, drill pipe, the annulus between the drill pipe and hole.
P_t = pressure differential required by the turbine.
P_b = pressure drop through the bit
GPM = rate of flow.

In practice, the pressure drop through the turbine and bit is more or less fixed by drilling requirements. The pressure loss in the system is improved by large surface connections and drill pipe.

Method of drilling. The no load or runaway speed of the turbine is about twice the optimum operating speed. At the start of drilling, the turbine is brought up to the maximum speed. The drill pipe is then slacked off until the turbine slows down to the operating speed, which indicates that the maximum power is being developed. Reports indicate that this speed of the turbine is presently being estimated by the vibration or sound of the drill stem. High speed produces a high pitch sound of low magnitude while the lower turbine speeds under load produce lower pitched sounds with an increasing magnitude. It is known that surface indicating tachometers are under development, which should improve the operator's ability to maintain proper turbine speeds.

During drilling, weight on the bit is varied slightly to determine the optimum drilling rate. Where the operator is unable to obtain correct loading or penetration within the speed and weight limits, the circulation rates are increased or decreased for more efficient operation.

Preparatory to coming out of the hole, normal procedure is to raise the bit a few feet off bottom and clear the tool before coming out. During drilling, the drill pipe is allowed to rotate periodically to prevent any build-up of cuttings around the pipe and also to reduce the possibility of washing around the pipe. This as accomplished by either releasing the brake on the rotary table for a few moments permitting the drill string to back spin or by rotating to the right a few turns. Through all operations, the circulating rate is maintained as near constant as possible. Nearly all Russian rigs using the turbodrill are equipped with pulsation dampeners to reduce vibration.

As far as possible, water is used as the drilling fluid since both the turbine operation and the drilling rate are considerably greater with water. Mud is used only where it is required to control formation pressures or for other necessary reasons.

The drill pipe in nearly all cases is selected to provide the lowest practical pressure losses in the system. In a number of the wells drilled, casing has been used as the drill string. Basically the tools and practices of turbodrilling depart from rotary practice only where the peculiar advantages of the turbine dictate. Many of the advanced rotary techniques are also applicable to turbodrilling and will improve the overall performance of this method beyond that which has been attained to date.

Acknowledgment

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P 501.741

EXCLUSIVE

Condensing gas drive, critical displacement process . . .

New Injection Method Affords Total Oil Recovery

By controlling composition of injected gas within a critical range, capillary forces in the reservoir are reduced to zero. Idea workable in all types of drives, irrespective of stage of recovery.

Norman J. Clark
W. P. Schultz
and
H. M. Shearin
Core Laboratories, Inc., Dallas, Texas

UNDER given conditions of reservoir temperature, pressure, and known composition of reservoir oil and gas, there is a definite composition of injected gas such that when combined with these reservoir hydrocarbons will form a critical mixture of a single phase where in the liquid (oil) loses its identity. By such a process, the capillary forces normally associated with an oil producing reservoir are reduced to zero, thereby releasing all the oil in the pore spaces to the critical mixture.

It has long been known that capillary forces existing at the interface between oil and water naturally inherent in most reservoirs control the amount of oil that can be recovered from that reservoir. The condensing gas drive, critical displacement process, in eliminating capillary pressures by a single phase mixture, makes it possible to displace this single phase completely in that portion of the reservoir through which it moves. In practice, it is probable that propane, ethane and rich gas will be mixed in predetermined proportions to make up this critical mixture to be injected into the reservoir. The process appears to be workable regardless of reservoir drive, or whether the reservoir is in its primary, secondary or final phase of operation.

How oil is recovered. The recovery of oil from pores of reservoir rock results from the displacement of oil by some fluid such as water or gas. Fig. 1 indicates the typical fluid

Editor's Note-

Most Promising Idea Since Waterflooding . . . a new era in oil recovery operations lies ahead. The very thought of recovering practically all the oil we find carries with it tremendous implications. The U. S. oil industry now is recovering only a little less than half the oil discovered. And, this has been with the aid of the very best techniques known. Now, comes a process whereby most of the oil found underground can be recovered, and not affected to a large extent by the type of reservoir drive or stage of recovery. This would mean that it is possible to double this country's recoverable oil reserves!

There will be limitations, to be sure. In most instances, as the authors point out, propane and ethane will be required to make up the critical composition of injected gas . . . and, this mixture will vary from reservoir to reservoir. Availability of propane and ethane in adequate quantities will be a controlling factor . . . which means that the oil field must be located in an area where ample supplies of these vital hydrocarbons are available at an economic advantage.

In all probability, compressors in considerable numbers will be required to handle the injected mixtures. The hopes which this revolutionary idea holds for the oil operator are nearly on a parallel with the promise the condensing gas drive, critical displacement process holds for the compressor manufacturer.

And, what it holds for this country, for private industry and the military alike, is startling to say the least. We would not be dependent completely upon foreign oil, even in a case of national emergency. And, those engaged in the frantic effort to find new sources of oil within our own boundaries might rest easier.

It is not likely that all this will transpire overnight, but will require costly experimentation in both the laboratory and field, as well as take considerable time for individual reservoir study to select the best prospects. Waterflooding took a mighty long time to find widespread application. No doubt, the condensing gas drive process, too, will be around for some time before it is as well known as waterflooding is today. But, at last, engineers have found a key that promises to unlock the door to most of the oil tapped by the drill . . . and its successful application in the field will be nothing short of revolutionary.

distribution in the pores of a water-wet oil bearing sand. This illustration shows that water is distributed as a thin film adhering to the sand grains while oil occupies the center portion of the pore. Schilthuis[1] pointed out that such a distribution results from interfacial forces which will not permit a distinct gravitational separation of fluids due to density differences. Capillary pressure is the pressure differential across the oil-water interface. Magnitude of this force is a function of the curvature of the interfacial film. When the radius of curvature is small, the capillary pressure is high as shown on Fig. 1.

The recovery expectancy and characteristics of reservoir performance under different displacing mechanisms have been discussed in detail by Craze and Buckley.[2] These authors point out that generally, water drive recovery is expected to be greater than gas drive recovery when reservoir conditions are the same. The expected recovery by water drive ranges from 60 to 80 per cent while recovery by gas drive ranges from 30 to 80 per cent. Capillary forces existing in the reservoir help create a more efficient displacing front when water is the displacing medium, thereby effecting the higher anticipated recovery. Fig. 2 illustrates the displacement of oil by water. The interfacial film between oil and the displacing water will be cupped because the sand grains are already wet by water and the invading water tends to run ahead of the oil adjacent to the sand grain surface.

Such displacement is not perfect, however, since interfacial forces cause small droplets of oil to be formed as the front advances through the pores. Some of these droplets remain in the pores behind the front and cannot be produced.

Displacement of oil by gas differs considerably from displacement by water. Gas has a lower viscosity than oil and exists in pore spaces as a non-wetting phase. It tends to move ahead of the oil in the center of the pore channel as shown in Fig. 3. The wide range of gas drive recovery expectancy results from variations in such factors as sand permeability, oil viscosity, and structural relief.

DISPLACEMENT BY WATER

The mechanism of oil displacement by water has been studied by many authors. A very complete discussion of this basic mechanism is presented in the paper by L. A. Rapaport.[3]

Fig. 4, which is a sequel to Fig. 1, shows how high capillary pressure gradients occur from inside tight permeability lenses causing oil to be ejected through the center of the pore channel and water to be imbided along the surface of the face of the sand grains. This moves oil out of tight portions of rock into high permeability portions where it can be displaced further to the well bore. Fig. 5 illustrates the condition in pore spaces after water has entered and oil has been ejected into more permeable rock. The radius of curvature of the interfacial film has decreased within a given pore and capillary pressure has reduced accordingly.

If no water is being forced through the pore channel by a water drive or injection project, oil will be trapped since no capillary pressure gradient exists between pores. When the oil saturation is reduced to some lower value than original, and the thread of oil illustrated in Fig. 5 becomes small, the thread at point A breaks because of the tension in the interfacial film.

Fig. 6 illustrates this condition; and, after this occurs, water may not be forced through the pore channel under any pressure gradient capable of being applied in the sand, by either a water drive or an injection project, and will most likely not move the entrapped oil droplets. Interfacial or capillary forces will resist the film being deformed to permit the contained oil in the droplet passing through the restrictions in the pore channel.

Capillary forces. Throughout many years, it has been recognized that capillary forces, particularly in water drives, tend to assist obtaining high recovery in nonuniform sands.

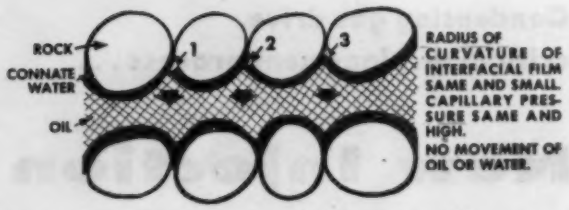

FIG. 1. **Original water and oil saturation** in pore spaces under equilibrium conditions.

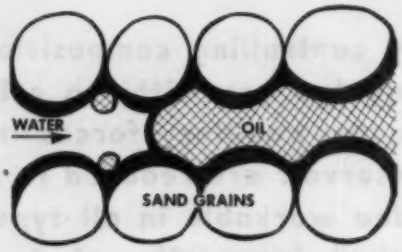

FIG. 2. **Capillary forces** which cause movement of oil through pore spaces.

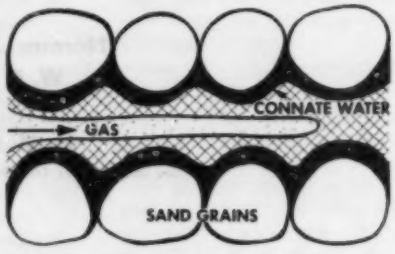

FIG. 3. **Natural displacement** of oil by water.

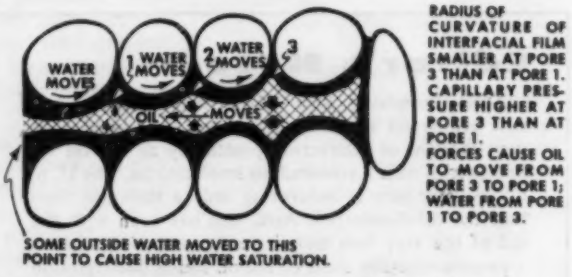
WATER MOVES
1
WATER MOVES
2
WATER MOVES
3
OIL
MOVES
RADIUS OF CURVATURE OF INTERFACIAL FILM SMALLER AT PORE 3 THAN AT PORE 1.
CAPILLARY PRESSURE HIGHER AT PORE 3 THAN AT PORE 1.
FORCES CAUSE OIL TO MOVE FROM PORE 3 TO PORE 1; WATER FROM PORE 1 TO PORE 3.
SOME OUTSIDE WATER MOVED TO THIS POINT TO CAUSE HIGH WATER SATURATION.

FIG. 4. **Natural displacement** of oil by gas.

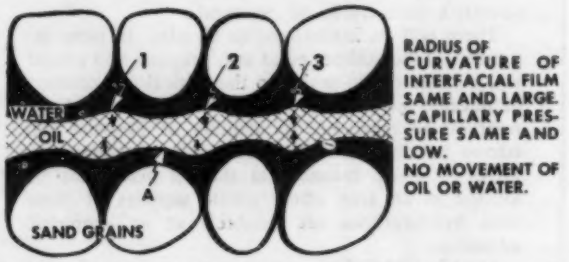

FIG. 5. **High water and low oil saturation** in pore spaces as it occurs at capillary equilibrium after the entry of outside water.

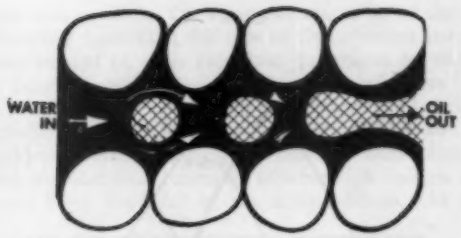

FIG. 6. **Oil being displaced by water,** showing high surface tension causing interfacial film to break at restriction in pore channel leaving oil behind the water front.

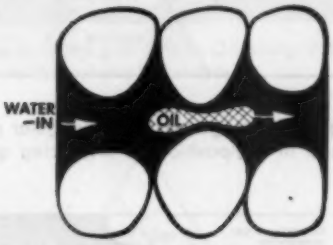

FIG. 7. **Residual oil being moved** through restriction and into producing stream by reducing surface tension in the interfacial film.

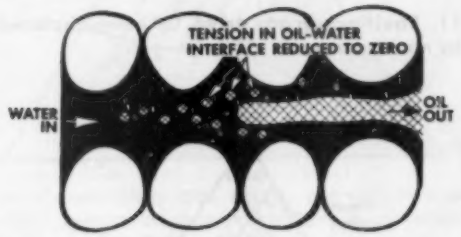

FIG. 8. **Total oil recovery** achieved by reducing the interfacial forces to zero and displacing oil by water.

But, even with this so-called high recovery, there still remains in all sands a considerable amount of trapped oil. Interfacial forces tend to assist oil recovery during stages of production when high oil saturation occurs in the reservoir rock, but that after some point in oil recovery has been reached, these same interfacial forces act in a different way to prevent further recovery of the remaining oil.

Reducing interfacial tension. Recovery of oil droplets held behind the invading water as shown in Fig. 6, can be accomplished by reducing the tension in the interfacial film, which allows the droplet to elongate and flow. This is shown on Fig. 7. To carry this further, it has been theorized that if the interfacial tension could be reduced to zero, or nearly zero, water would be miscible or nearly miscible with oil, and most all the oil could be displaced ahead of a displacing water front. No discussion will be presented of the practical problem created in the surface separation of oil dissolved in water by such a recovery process.

For a number of years, soaps, detergents, and various surface active agents have been utilized both in the laboratory and in the field in experimental work to develop a practical method of attaining complete oil displacement by reducing interfacial forces in the reservoir at residual oil saturation. To date, a practical field method is not available whereby total oil recovery can be realized by water displacement.

DISPLACEMENT BY GAS

Recognizing that to obtain total oil recovery will require reducing interfacial forces to zero, research organizations have been working on the problem along other lines for several years. *It now appears the industry is across the threshold of a new era in oil recovery operations. Total oil recovery is now capable of being realized from that portion of reservoirs through which a proper material can be injected.* The best material, while different for different reservoir conditions, appears to be natural gas rich in certain intermediate components, usually ethane and propane.

"Miscible displacement." In 1950, Whorton and Kieschnick, and in 1953, Slobad and Koch, all with the Atlantic Refining Company, proposed that for high shrinkage undersaturated oils existing at high pressures, a rich gas injection process could recover unusually high percentages of oil. This was to be accomplished by a "miscible displacement" between the displacing gas and the displaced oil. It was concluded in the latter paper that such a process "depends mainly upon the composition of reservoir fluid and the injection pressure and variables of lesser importance are the composition of injection gas and reservoir temperatures."[5] In 1955, Stone and Crump[6] of the Humble Oil and Refining Company expanded on the basic approach to oil displacement by enriched gas, and concluded that "use of condensing gas drives would result in increased oil recovery from many reservoirs during either primary or secondary phases of production."

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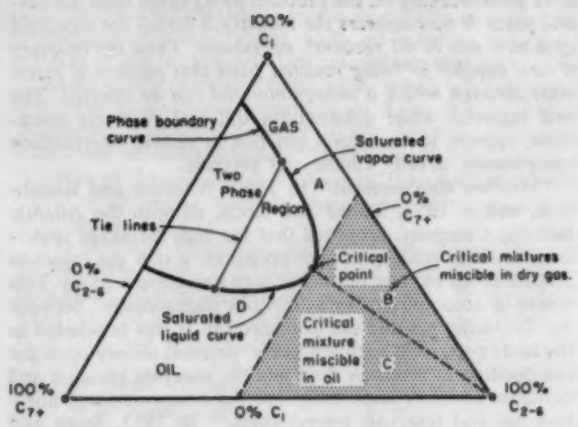

FIG. 9. **Triangular graph** showing physical conditions of hydrocarbon systems at fixed temperature and pressure conditions.

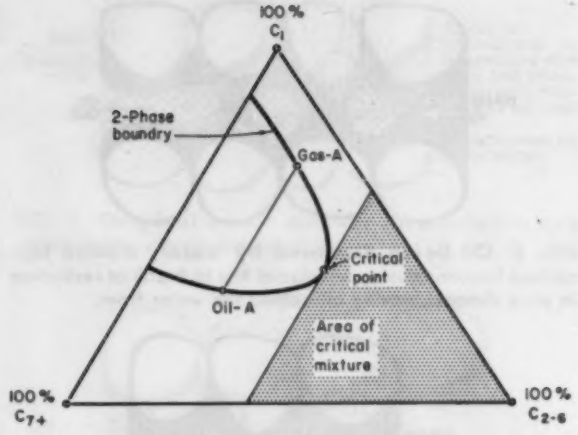

FIG. 10. **Equilibrium gas drive.** Triangular graph showing no change in composition of displacing gas and displaced oil.

FIG. 11. **Equilibrium gas drive.** Oil being displaced from sand by equilibrium gas.

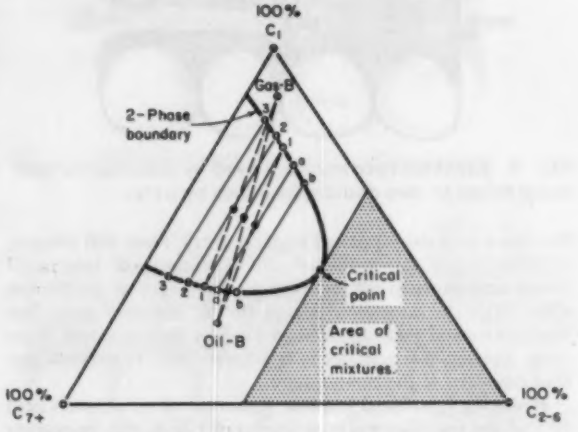

FIG. 12. **Vaporizing gas drive.** Triangular graph showing changes in composition of displacing gas and displaced oil.

Use of composition graphs. In reviewing the various processes that occur during displacement of oil by gas, it is helpful to use triangular graphs as shown in Fig. 9. Here, the complex hydrocarbon system is arbitrarily shown in three groups of components analogous to a three component system. This is not thermodynamically rigorous, but presents a picture which is qualitative and which is practical in explaining what actually happens thermodynamically in a complex hydrocarbon system. In Fig. 9, any point within the triangular graph represents some hydrocarbon system with specific amounts of each of the three groups of components: methanes (C_1), ethane (C_2) through hexane (C_6), and heptane and heavier components (C_{7+}). Conditions for a given graph are at some constant temperature and pressure.

Critical mixtures. There is an area of the graph surrounded by a loop called the phase boundary curve within which the mixture exists in two phases—gas and liquid. Tie lines are shown cutting across the two phase region. These tie lines terminate at points on the saturated vapor curve and the saturated liquid curve respectively. These two points represent a saturated gas and a saturated oil that would be in equilibrium with each other if placed in contact at the temperature and pressure existing for the given diagram.

The limiting tie line is a point representing the critical mixture for the existing temperature and pressure. Mixtures represented by points above and to the right of the saturated vapor curve are gas (area A), and mixtures represented by points below and to the left of the saturated liquid curve are oil (area D).

Mixtures with greater percentages of intermediates or those lying to the right and down are in the zone that is either liquid or gas if they can be visibly defined in the presence of one or the other. This is the area of critical mixtures. A portion of this critical area lies upward and to the right of the two-phase area (area B) and mixtures in this area have less heptane plus (C_{7+}) components and are miscible in mixtures represented by points in the gas area. The other portion of the critical area of mixtures lies down and to the right of the two-phase area (area C). Mixtures in this area have less methane (C_1) component and are miscible in mixtures represented by points in the oil area.

Molecular behavior. The molecular behavior of hydrocarbon systems is governed by three important physical phenomena: (1) pressure; (2) kinetic energy associated with temperature; and (3) molecular attraction. Oil and gas, either separate or together in a reservoir, may undergo drastic physical changes in state as they move from point to point in a reservoir because of the governing features of molecular behavior. Fundamentals of this behavior are discussed in detail by Clark in the literature.[7] It is upon these basic fundamentals that the phase behavior of reservoir oil and gas in the process of recovery of reservoir oil by gas displacement is to be explained.

Equilibrium Gas Drive

An equilibrium gas drive is the nomenclature given to the process of oil displacement by gas where little or no mass component exchange occurs in either the oil mixture being displaced or the gas mixture displacing the oil. Fig. 10 and 11 illustrate this type of displacement. In Fig. 10, gas-A and oil-A are located at the terminal points of a tie-line across the two-phase area on the saturated vapor curve and saturated oil curve respectively. Fig. 11 is a gas-oil saturation distance diagram showing that partial oil displacement occurs

with this type of drive. Capillary characteristics of the rock are controlling features in this type of displacement and after a certain amount of oil is produced, gas moves on through the oil bearing pore spaces, and the capillary forces cause the rock to be highly retentive to the remaining oil. Relative permeability concepts fit this system of displacement and the Buckley-Leverett[2] displacement relations were developed to permit mathematical treatment of saturation changes in an oil system being displaced by gas at equilibrium. The practical application of this displacement mechanism in conjunction with volumetric balance and unsteady state water influx calculations which are used for a complete reservoir study is discussed in detail by Wooddy and Moscrip.[8]

Even though conditions are all favorable, such as high structural relief, high permeability and low oil viscosity, considerable quantities of oil will remain as residual oil in the reservoir if equilibrium gas drive is the operating mechanism. Even pressure maintenance may provide only small additional quantities of oil, and that mainly is through the prevention of oil shrinkage.

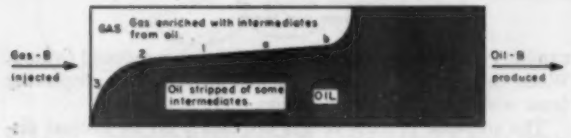

FIG. 13. **Vaporizing gas drive.** Oil being displaced from sand by gas which causes oil to vaporize.

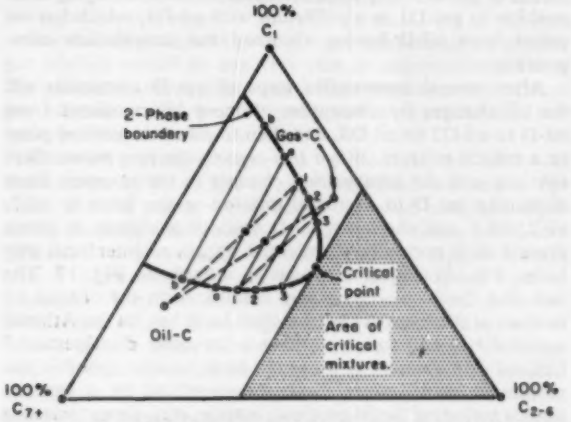

FIG. 14. **Condensing gas drive,** non-critical displacement. Triangular graph showing changes in composition of displacing gas and displaced oil.

FIG. 15. **Condensing gas drive,** non-critical displacement. Oil being displaced from sand by condensing gas without creating a critical mixture at the front.

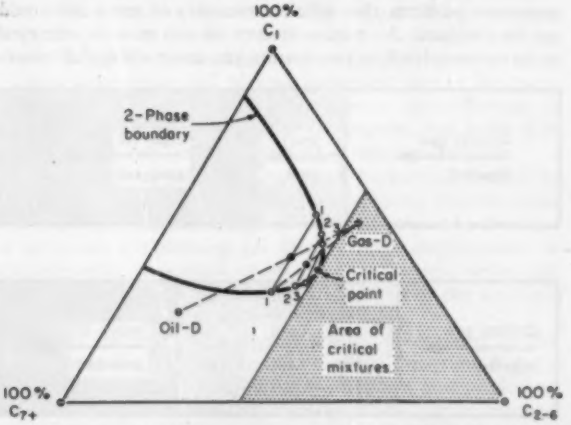

FIG. 16. **Condensing gas drive, critical displacement.** Triangular graph showing changes in composition of displacing gas and displaced oil.

Vaporizing Gas Drive

A vaporizing gas drive is that process of displacement by gas where components in the oil vaporize into the displacing gas phase. A greater oil recovery may be gained by this type of displacing process than will be obtained by the equilibrium gas drive. Such additional oil may be only slight and will contain mostly the intermediate components of the oil, all of which may not be recoverable from the gas at the surface. Fig. 12 and 13 illustrate the vaporizing gas drive process.

The stepwise process of oil displacement occurs first with contact of oil-B with gas-B. A mass exchange of components in the gas and oil occur as the two phases tend to come to equilibrium in the presence of each other. Assuming equilibrium occurs, the oil composition changes to oil-B1 and the gas changes to gas-B1. Oil-B has lost both in intermediate components (C_2-C_6) and heavy components (C_{7+}) while gas-B has absorbed these components.

This mass transfer takes place as a result of molecular forces associated with the existing pressure, temperature, and hydrocarbon composition of gas-B and oil-B. More gas-B contacts oil-B1 in the displacement process, and, when equilibrium occurs, this oil-B1 composition changes to oil-B2 and gas-B composition changes to gas-B2. After several consecutive steps of gas-B contacting oil, additional oil components vaporize until the oil composition becomes oil B-3 and gas-B becomes gas-B3 when equilibrium occurs.

During the second step, gas B1 formed by contact of gas-B and oil-B, moves ahead and contacts more oil-B. This results at equilibrium with gas-Ba and oil-Ba being formed. After successive intermediate steps, gas at the front becomes gas-Bb in contact and equilibrium with oil-Bb. The quantity of intermediate and heavy components in the gas varies and gets greater as the gas moves further into the oil in the displacement process. This enrichening process causes the oil to get leaner of intermediates in the areas through which most gas has moved as shown on Fig. 13.

Condensing Gas Drive

A condensing gas drive is that process of oil displacement by gas where components in the gas condense in the oil which it is displacing. This mechanism occurs under two conditions: (a) noncritical displacement, and (b) critical displacement.

Noncritical displacement. A condensing gas drive noncritical displacement is illustrated by Fig. 14 and 15. A greater oil recovery may be expected from this type of displacement than from the vaporizing gas drive. Maximum advantage is not obtained, however, as capillary retentive forces are present because two phases—gas and oil—remain present throughout the displacement process. Chief advantage is an absorption of intermediates from gas into oil, swelling the oil and causing more of the oil originally in place to be displaced ahead of the gas front.

The stepwise process of gas displacing oil occurs first with contact of gas-C with oil-C. A mass exchange of components between these two materials results in gas-C losing some intermediates and changing composition to gas-C1 in equilibrium with oil-C1, which has resulted from oil-C having absorbed the intermediate components.

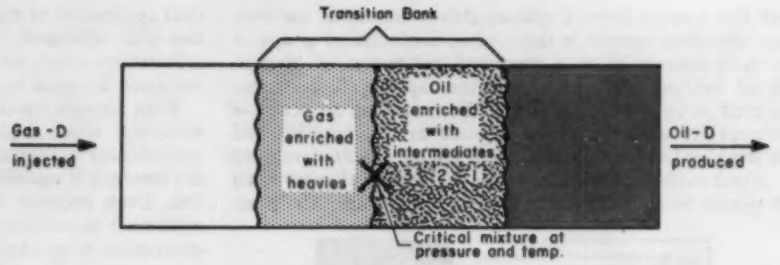

FIG. 17. **Condensing gas drive, critical displacement.** Oil being displaced from sand by condensing gas creating critical mixture and transition bank at the front.

After several consecutive steps of gas-C contacting oil, it changes by absorption of more intermediates from oil-C to oil-C1 to oil-C2 and finally to oil-C3 as shown on Fig. 14 and 15.

During the second step, gas-C1 formed by contact of gas-C and oil-C, moves ahead and contacts more oil-C. This results at equilibrium with gas-Ca and oil-Ca being formed. After successive intermediate steps, gas at the front becomes gas-Cb in contact and equilibrium with oil-Cb. The quantity of intermediates and heavy components in the gas varies and becomes less as the gas moves further into the oil in the displacement process. This condensing gas process causes the oil to get richer with intermediates in the areas through which most gas has moved as shown on Fig. 15.

Critical displacement. A condensing gas drive, critical displacement is illustrated in Fig. 16 and 17. *Complete recovery of oil in the sand through which gas moves may be expected by this type of drive.* This results from the fact that capillary retentive forces of the sand to oil is reduced to zero. When this occurs, the oil is pushed ahead of the displacing front with complete piston action.

The stepwise process of gas displacing oil by critical displacement occurs first with contact of gas-D with oil-D. A mass exchange of components between these two materials results in gas-D losing some intermediates and changing composition to gas-D1 in equilibrium with oil-D1, which has resulted from oil-D having absorbed the intermediate components.

After several consecutive steps of gas-D contacting oil, the oil changes by absorption of more intermediates from oil-D to oil-D2 to oil-D3, and then to oil at the critical point or a critical mixture. *When this occurs, the two phases flash into one and the composition changes* in the reservoir from displacing gas-D to a critical mixture at the front to oil-3, oil-2, oil-1 and displaced oil-D without a change in phase present as is normally represented by gas-oil interfacial surfaces. This transition is shown as a bank on Fig. 17. The fact that the d.splacing gas is miscible with the critical oil mixture at the front of the transition bank has led the Atlantic authors[4,5] to call this type drive a "miscible displacement." Critical displacement is preferred here because miscible displacement could cover displacement of oil by a host of liquids including liquid propane, butane, etc., almost miscible in oil, but which might be impractical to use as a displacing agent because of economics.

Control of injected gas composition. To obtain a condensing gas drive, critical displacement, *it is most important for the composition of the gas injected to be controlled so that sufficient intermediates are present to make the composition a critical one.* Because of this, a gas having such composition is referred to as a critical type gas. A gas of this nature would be represented by one with a composition occurring in area B on Fig. 9. It is fortunate that the composition of the gas is the important factor because this means that control can be maintained on any injection project. If it were the composition of the displaced oil that presented the important problem, then efficient recovery of many oils could not be obtained. As it is, *most any oil can now be expected to be recoverable by a condensing gas drive, critical displace-*

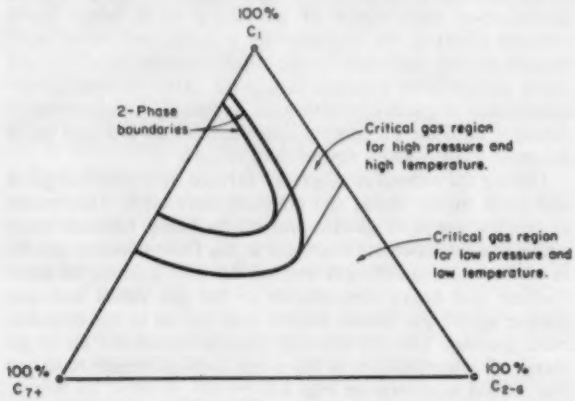

FIG. 18. **Effects of pressure and temperature** on the composition of critical gas as shown by triangular graph.

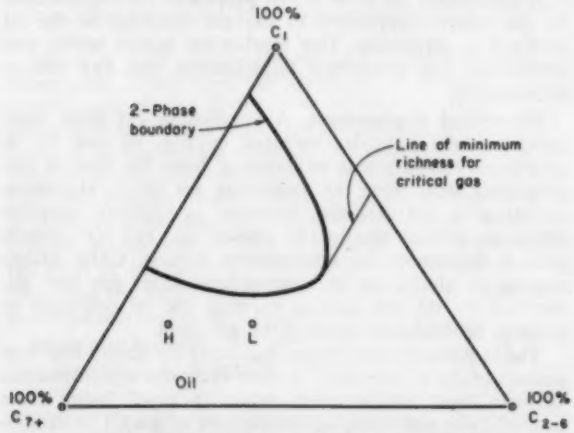

FIG. 19. **Criteria for determining composition** of a critical gas for a given reservoir pressure and temperature.

FIG. 20. **Comparison of transition banks** in displacing light and heavy oils in a condensing gas drive, critical displacement process.

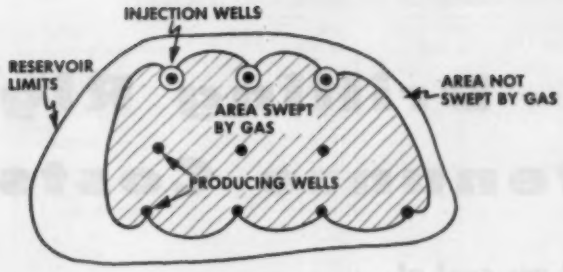

FIG. 21. **Pattern efficiency** of displacement by gas drive.

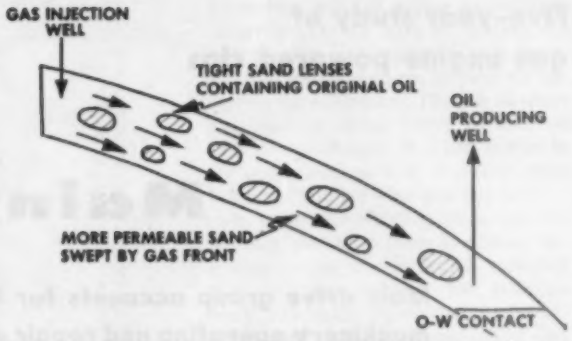
GAS INJECTION WELL
TIGHT SAND LENSES CONTAINING ORIGINAL OIL
OIL PRODUCING WELL
MORE PERMEABLE SAND SWEPT BY GAS FRONT
O-W CONTACT

FIG. 22. **Conformance efficiency** of displacement by gas drive.

ment, provided a critical gas composition can be obtained for injection purposes.

For low displacement pressure and temperature, a critical gas mixture would be one very rich in intermediates. For a high displacement pressure and a high temperature, a critical gas mixture would be one composed of considerably less intermediates as shown on Fig. 18.

Effect of gravity. Comparison of the light and heavy oil experiments by Stone and Crump[6] presented evidence to the effect that the gravity of oil being displaced had little effect on the displacement process. For example, heavy oil H and light oil L, shown on Fig. 19 will both be displaced through critical displacement by a given critical gas at the existing pressure and temperature. By their respective location on the composition chart, heavy oil generally requires contact with more gas and a greater amount of mass component exchange before it becomes a critical mixture miscible in the injected critical gas. Fig. 20 illustrates this and shows that the transition bank of mixtures at the displacing front is short for light oil compared to that for heavy oil.

After transition zone established. Once the transition bank at the front is formed, it is believed that critical gas requirements behind the front may be limited and that for a large part of a project, injected gas can be dry, which is miscible in the critical gas immediately behind the transition bank. If the project were attempted with a condensing gas drive but not using a gas of sufficient richness to be a critical gas, considerably more intermediates would be required for the entire project and considerably less oil recovery would be obtained.

Requirements for some additional supply of critical gas behind the transition bank are necessary because of the variation in rock permeability which tends to permit low viscosity displacing gas to move in high permeability sand sections ahead of high viscosity oil in lower permeability sand sections. Gravity segregation will play an important part in the maintenance of a transition bank because of the difference in density between gas and oil. For this reason, reservoirs with structural dip will be better suited for injection projects.

Limitations on recovery. As stated earlier, oil cannot be displaced from pore spaces which a displacing material does not reach and, therefore, a given reservoir cannot be denuded of all its oil. Condensing gas drive, critical displacement, is attained only as a result of an injection project where gas composition is controlled and only a portion of the reservoir can be reached by injected gas.

Pattern efficiency of a project will be determined by the geometry of the reservoir and the injection program. Fig. 21 shows a hypothetical reservoir with injection and producing wells and the pattern area through which oil can be reached by an injection project.

Within the pattern area, there will be isolated parts of the reservoir rock through which injected gas cannot be forced as shown on Fig. 22. This gives rise to a loss in recovery because these isolated parts of the reservoir contain oil in the pattern area of the reservoir. The per cent of rock in the pattern area through which the displacing fluid will move is denoted as the conformance efficiency. Recovery efficiency for any project therefore depends upon pattern efficiency, conformance efficiency, and the pore space displacement efficiency in the conformance portion of the reservoir. Condensing gas drive, critical displacement, permits efficiency of displacement in the conformance portion of the reservoir to be complete.

Setting up a project. Planning a project to apply condensing gas drive, critical displacement, should commence with the determination of what constitutes a critical gas in the presence of reservoir oil at existing temperature and pressure. This is accomplished only by trial and error laboratory examination utilizing reservoir oil and various gases in the experiments. In carrying out a project, a requirement will be that a critical gas can be made economically available at the site of the project.

A complete reservoir study must be made to determine the economics of such factors as additional oil to be obtained by a condensing gas drive, critical displacement project, as compared to other types of recovery mechanisms, including primary operations.

Economics of a project will involve the amount of gas available, quantity of intermediates, especially ethane and propane available and required, reservoir pressure and compressor requirements. Availability of large quantities of ethane and propane in a given area may make a low pressure, heavy oil project successful. In another area, lack of sufficient quantities may make a light oil project an economic failure even though added benefits may be obtained by pressure maintenance with one or the other gas displacement process operating.

Total recovery possible. One of the most interesting aspects of the use of ethane and propane in the project is that most of this material can be expected to be recovered if the project is engineered and carried out properly. *Condensing gas drive, critical displacement, process now offers a method whereby total recovery of oil can be obtained in parts of a reservoir whether the reservoir is in its primary, secondary, or even third and last phase of operations.*

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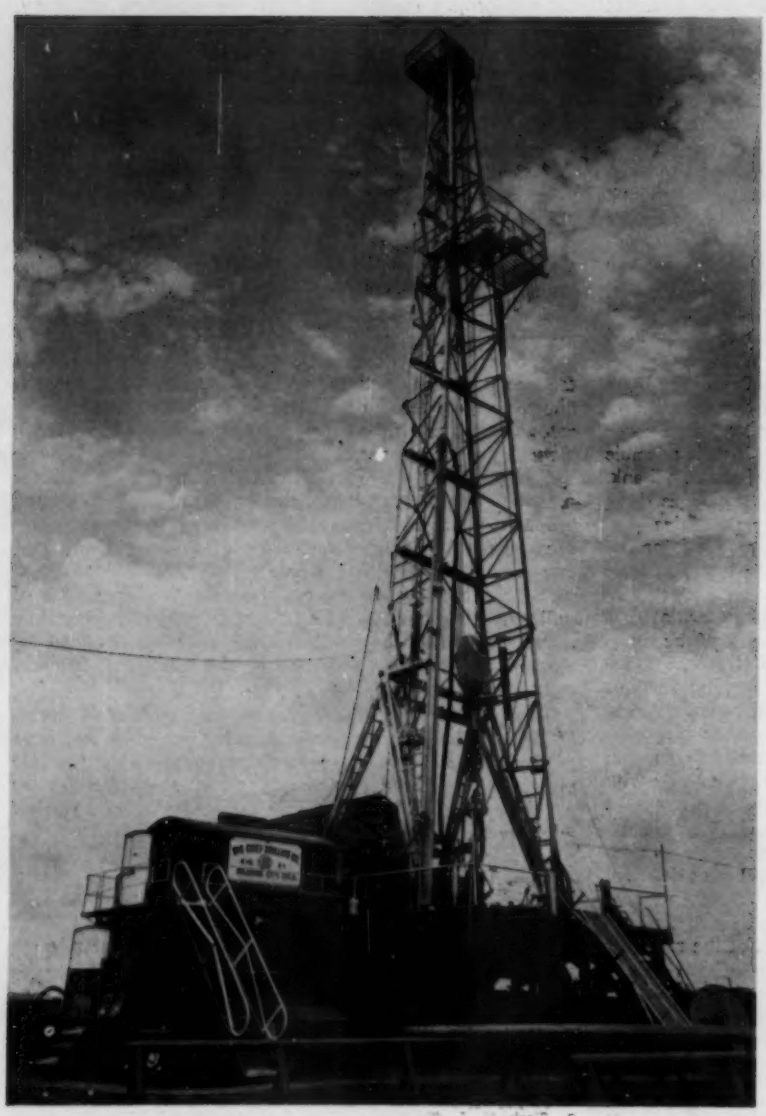
Five-year study of gas engine powered rigs

Drilling Rig Maintenance Costs

Main drive group accounts for 42 per cent of machinery operating and repair expenses. From 1950-1955, wages increased 26.2 per cent.

Robert W. True
Big Chief Drilling Company, Oklahoma City, Oklahoma



It costs money to maintain a rig, such as this one, in peak operating efficiency. Here's how much it actually costs....

ACTUAL costs of maintaining and operating an oil field drilling rig have increased considerably since 1950. Cost comparisons presented are limited to the operation of gas engine rigs. The mast or derrick and its substructure are essentially investment items of equipment and are subject to practically no maintenance. Therefore, these items are not covered.

It must be realized that this report deals with maintenance cost only and does not include such other items of rig operating expense as depreciation of capital investment, insurance, cost of supervision, overhead expense, rig moving costs, fuel and water charges, taxes, costs of bits and consumable supplies, or trucking and transportation. These costs vary with geographical location and geological conditions and are not considered maintenance expenses.

The summation of maintenance costs presented does not represent the total cost of owning and operating a drilling rig. This analysis of rig operating costs covers the period from 1950 to 1955. Rigs discussed fall within four depth ranges: (1) 0 to 5000 ft; (2) 5000 to 8500 ft; 8500 to 12,000 ft and 12,000 to 15,000 ft.

To examine each item which contributes to maintenance costs would become too involved. Therefore, these costs are grouped in such a way whereby they can be properly discussed. Hence, the maintenance expenditures were divided into five sections (Table 1).

1. Rig operating expense — crew labor.
2. Major drive group.
3. Drill string.
4. Mud pumps.
5. Miscellaneous equipment and expense.

These groups were not selected to confine any one item to each section, but only to pinpoint and segregate the major items of cost.

Presented at the ASME Petroleum Conference held in Dallas, Texas, Sept. 24-26, 1956.

TABLE 1. Daily drilling rig maintenance expense.

Depth Rating	5000′	8500′	12,000′	15,000′
1. Rig operating labor costs	$286.45	$288.45	$347.10	$347.10
2. Main drive group				
Drawworks	10.99	22.06	24.30	34.16
Compound	19.85	19.94	30.15	24.25
Engine drive group	18.90	25.68	28.60	30.45
Chain	5.67	7.52	10.26	14.41
Oil and grease	20.48	31.06	30.95	28.61
	$ 75.89	$106.26	$114.06	$131.88
3. Drill string and tools				
Slips, tongs	4.07	4.94	6.19	6.43
Block, hook, elevators	1.67	2.94	2.14	3.67
Swivel	1.94	2.22	5.22	5.28
Wire line	5.62	9.22	11.37	16.16
Rotary table	2.98	4.17	2.97	1.76
Drill pipe	2.86	5.27	9.27	9.30
Drill collars	3.85	14.44	16.23	18.40
Kelly subs	4.55	2.32	6.92	5.82
	$ 27.49	$ 45.72	$ 60.41	$ 65.82
4. Pump	$14.44	$26.71	$41.36	$50.43
5. Miscellaneous equipment				
Air compressors, wire line guides, rollers, swivels, rig-up chain, etc.	2.50	5.86	$ 8.79	$ 10.96
Welding	4.99	7.67	5.78	8.31
B. O. P.	1.60	2.14	2.80	3.63
Electrical equipment				
Rig supplies, wrenches, hand tools, pipe fittings, paint, etc.	2.37	2.15	4.91	2.90
	23.97	30.55	33.85	37.40
	$35.43	$ 49.27	$ 55.78	$ 64.19
Total	$441.70	$516.41	$618.71	$660.42

TABLE 1a. Drilling rig maintenance expense.

Depth Rating	5000′	8500′	12,000′	15,000
	Engine Specifications			
Number of engines	2	2 & 3	3	3
*Rated hp	450	750	1350	1620
Cabin-to-rig-place rent (all engines)	3924	5788	9696	11,133

*Maximum horsepower, bare engine operating at sea level, 60 F air temperature, rated r.p.m.

In addition, since these costs are termed average for the years 1950 to 1955, one should realize the resulting figures do not completely represent day operating costs. One exception does exist, however. Rig operating labor cost of this report reflects the total expense at the present time. This was done in order that, as close as possible, the cost of operating these rigs in present day drilling could be determined.

Rig Operating Expense

To fully cover rig maintenance costs, the necessity for adding rig operating labor to actual maintenance and repair charges should be realized. Rig operating costs can be directly associated with the morale and efficiency of drilling crews. The most efficient and best qualified crew will work where they receive the highest salary. Those workers of less know-how will fall in line accordingly. Therefore, to be sure of getting the best possible crew members, it is essential that top field wages be paid for operating the equipment. There is no short cut, such as cheap labor, to save on operational charges. It is just as true in rig operations as it is in every other business "you get what you pay for."

In some active drilling areas, rig contractors use cheap labor to reduce operating costs, consequently reducing their bidding estimate for contract work. Subnormal rig maintenance practices exist in such an operation and costly rig down time for needy rig repairs is frequent. In addition, the hazards while working under these conditions increase and result in an increase in injury frequency among the crew men.

In Table 1, the labor costs vary $58.65 between the two smaller rigs and the 12 to 15,000-ft class. This is due to the fact that the small rigs are operated with four-man crews and the larger rigs carry the customary five-man team.

One fact that has steadily increased rig operating charges is the gradual increase in wage rates. As shown in Fig. 1, labor charges for a five-man crew in 1950 were $273.10 per day and these same men received $347.10 per day

TABLE 2. Circulating horsepower vs operating expense

Depth rating	5000′	8500′	12,000′	15,000′
Horsepower available to drawworks and pumps	450	750	1350	1620
Total cu in. displacement of engines	3924	5788	9696	11,133
Horsepower rating of main pump	350	619	825	825
Maximum hp delivered to main pump at rated total depth	235	415	525	600
Cost per day per pump	$14.44	$26.71	*$34.20	*$42.20
Cost per day per 100 hp delivered	$ 6.10	$ 6.40	$ 6.60	$ 6.10

*Allowance made for additional pumps used on larger rigs.

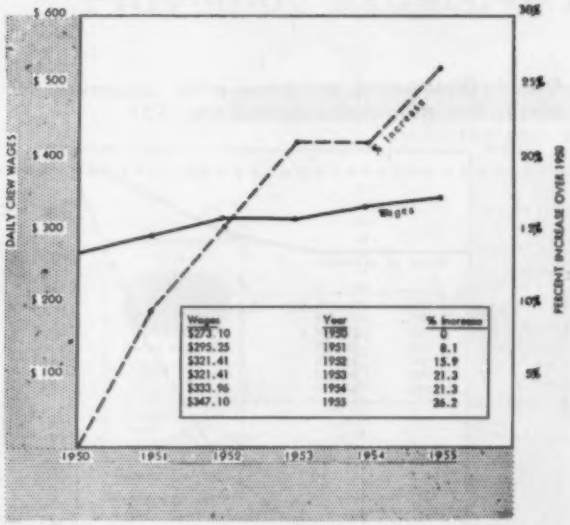


FIG. 1. **Daily rig operating expenses** incurred by crew wages over 5-year period and the per cent increase based on 1950 wages.

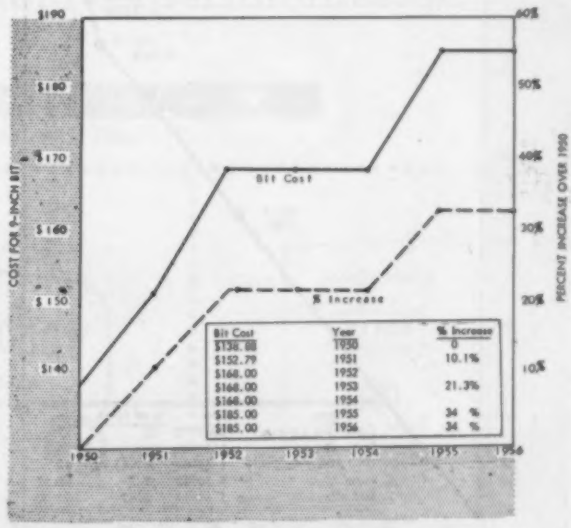


FIG. 2. **Cost for 9-in. bit** over 6-year period, and increase in cost since 1950.

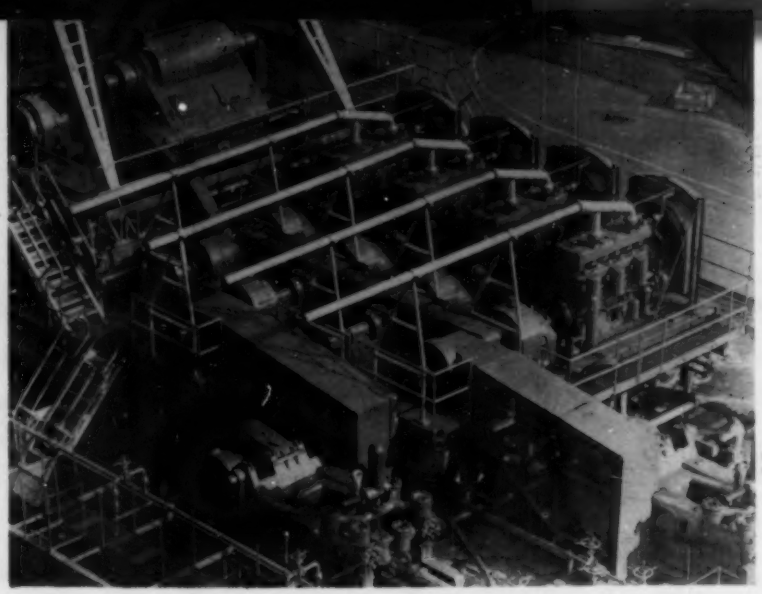
while working in 1955. This represents an increase of 26.2 per cent in wage raises alone.

Main Drive Group

The main drive group is the heart of any drilling rig. Success of the drilling operation depends upon the maintenance procedures carried out on these units. This group represents 20 per cent of the total operation cost or 42 per cent of the machinery operating and repair expenditure, excluding labor. Items included in this group are: Engines, drawworks, compound (or transmission), and lubricants.

The primary concern of any rig operator is to receive the maximum amount of horsepower at the lowest possible rate. It has been the policy of some operators, therefore, to pack additional horsepower into a rig so that it can exceed its nominal depth rating. Care should be taken, however, whereby the pressure ratings of pumps, drawworks hoisting maximum, etc. are not exceeded. By having more horsepower available through the compound and drive group, the engines can be operated in a range well below their maximum horsepower output. This reduces maintenance expense.

Table 3 points out the fact that rigs provided with excess horsepower can be operated at a reduced cost per horsepower used. On the 8500-ft rig supplied with 750 hp, the horsepower used in pumping operations is 515 or 67 per



Main drive group takes 42 per cent of machinery operating and repair expenses. This group consists of engines, drawworks and compound.

TABLE 3. Cost of horsepower during drilling operations.

Depth rating	5000′	8500′	12,000′	15,000′
Horsepower available to drawworks and pumps	450	750	1350	1620
Total cu in. displacement of engines	3924	6788	9696	11,133
Maximum hp used at rated total depth during drilling operations	295	515	660	870
Cost per 100 hp delivered per day	27.5	20.6	17.2	15.05
Per cent of maximum hp available in use	65.2%	67%	49.8%	53%

TABLE 4. Wire line expense.

Rig size	5000′	8500′	12,000′	15,000′
Hoisting load at maximum depth	105,000	162,000	225,000	265,000
Ton miles per trip with drill string	98	204	340	481
Cost per ton mile	.097	.097	.086	.086
Wire line cost per trip	$9.50	$19.20	$29.25	$41.50

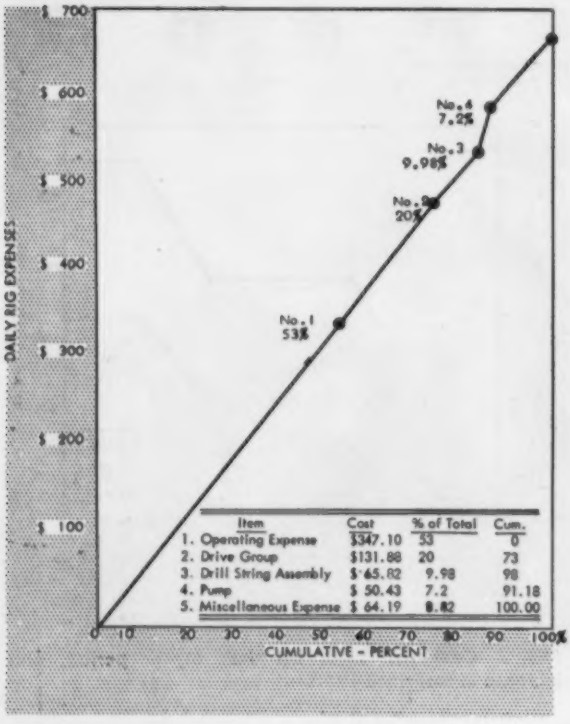
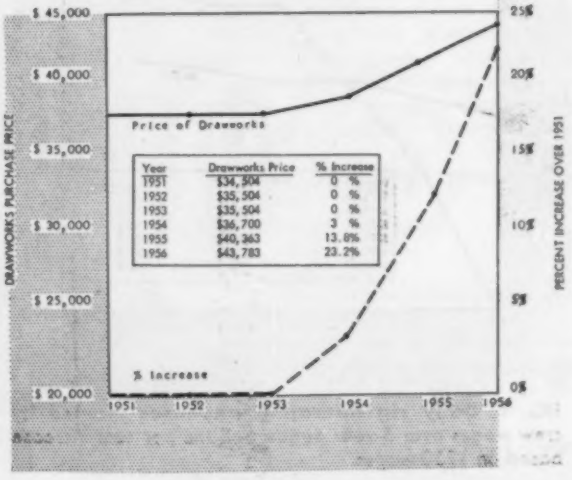

DAILY RIG EXPENSES
$ 700
$ 600
$ 500
$ 400
$ 300
$ 200
$ 100
No. 4 7.2%
No. 3 9.98%
No. 2 20%
No. 1 53%
0 10 20 30 40 50 60 70 80 90 100%
CUMULATIVE - PERCENT
Item | Cost | % of Total | Cum.
1. Operating Expense | $347.10 | 53 | 0
2. Drive Group | $131.88 | 20 | 73
3. Drill String Assembly | $ 65.82 | 9.98 | 98
4. Pump | $ 50.43 | 7.2 | 91.18
5. Miscellaneous Expense | $ 64.19 | 8.82 | 100.00

FIG. 3. **Cumulative costs** of all items of daily rig maintenance expenses broken into the various items.

FIG. 4. **Drawworks purchase price** comparison for past 5 years, and per cent increase over 1951.



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T-8

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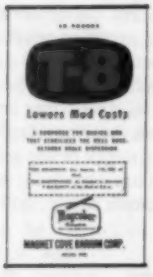

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Wire rope costs on a ton-mile basis are slightly less on the larger rigs due to the greater hoisting loads.

Daily drill pipe expense for big rig (12 to 15,000 ft) is about $7.55 per day and on smaller rigs, about $4.20 per day.

cent of the available total. The 15,000-ft unit supplied with 1620 hp uses a maximum of 870 hp or 53 per cent of total for drilling use. Cost per 100 hp per operating day on the 8000-ft rig was $20.60; corresponding expense per 100 hp per operating day on the larger rig (15,000-ft) was $15.05. This constitutes a reduction 22.3 per cent in horsepower costs for the larger rig. The resulting comparison indicates that the smaller rigs should be equipped with more horsepower than presently available. It might be added that since these figures were compiled in 1955, Big Chief Drilling Company has purchased a rig confirming these conclusions.

An 8500-ft rig was assembled having a drive unit (compound-engines) of 1080 maximum horsepower. This unit will have a lower daily operating cost than average powered with less than 900 hp maximum.

If the 8500-ft rigs had been previously supplied with ample horsepower five years ago a notable saving could have been realized. In other words, if these rigs could have operated at $15.05 per 100 hp, a savings of $8700 would have been realized yearly. In addition, applying the savings to the investment cost for this added drive unit, it would have been sufficient compensation to cover this added cost in three years running. Also, the rig would have had additional horsepower for emergency use.

Drill String Tools

It would appear from the totals in Table 1 that depth of a well has a great deal to do with the upkeep of the drill string tools. In this category, included are: Drill pipe, drill collars, wire line, rotary table, traveling and crown blocks, hook, tongs, swivel, and associated tools. Upon close examination of the items listed, however, it is found that the cost is primarily due to three items: Wire lines, drill pipe, and drill collars.

Wire line. Investigating the wire line costs further, the additional expense increase on the larger rigs is due to the ton miles incurred while hoisting pipe. As shown in Table 4, the ton miles at maximum depth for the 8500-ft rig is 204 compared to 481 for the 15,000-ft rig. The wire line cost per day on the larger rig is 2.1 times the medium size unit; records show that relative cost per ton mile absorbed while hoisting differs only by $.01; $.097 for the 8500-ft and $.086 for the 15,000-ft rig.

Drill pipe. Many factors affect the daily expense of drill pipe costs. In the case of the two larger size rigs, they were used on wells where crooked hole conditions existed. Therefore, abnormal tool joint wear was present which in turn necessitated the premature building up of the tool joints with tungsten carbide to prevent total tool joint destruction. However, even though this pipe was exposed to these conditions, total life of the drilling string was not affected. It is the author's opinion that normal drill pipe expense for rigs of such size (12 and 15,000 ft) would be approximately $7.55 per day and on the smaller units an average operating expense of $4.20 is expected.

Drill collars. Drill collar expense can vary greatly from well to well for any size rig. This is primarily due to the casing and hole size program. A rig operating in areas where controlled deviation of the hole is necessary must use drill collars of additional size and weight, i.e., 9⅞-in. hole and 8-in. collars, etc. It is found that under these circumstances high tool joint repairs exist. On the other hand, well costs compiled on units drilling in areas where the well bore does not deviate greatly, i.e., 9-in. hole, 7-in. collar, show a reduction in drill collar expense.

In addition, it is common practice to use longer drill collar strings on the larger rigs to increase penetration rates in the harder formations encountered at the greater depths. Therefore, the overall cost of drill collar maintenance depends upon these points: Size of hole being drilled, depth of the well, whether oversize collars are used, and if controlled deviation while drilling is necessary.

Mud Pumps

The effect of higher operating pressures on mud pump costs is clearly indicated in the cost summary of Table 3.

The Author

Robert W. True is drilling engineer for Big Chief Drilling Company at its Oklahoma City headquarters. He attended Cameron A & M College and the University of Oklahoma where he received his BS degree in petroleum engineering. He worked as a roughneck, driller, and tool pusher for Big Chief in Kansas, Texas, Oklahoma, and throughout the Mid-Continent area. Upon completion of these tours of duty, he was moved to Big Chief's headquarters as drilling engineer. He served in the U. S. Navy during World War II prior to entering college.

Rigs operating in the shallow depth range have greatly reduced costs due to the lighter load incurred during pumping and drilling operations. The increase in horsepower requirements is almost doubled from the 5000-ft rig to the 8500-ft rig. Consequently, the pumping cost per day reflects the higher trend.

Due to the fact that the larger size rigs have two and sometimes three pumps for circulation purposes, allowances have been made in Table 3 to conform to the cost of operating one main circulating pump during drilling operations. In recent years it has been a practice of paralleling the main pumps in the initial drilling operations. This operation does not materially increase the daily operating costs due to the small percentage of time consumed in this operation as compared to the total drilling days consumed in drilling deeper holes.

1953, the average cost of these miscellaneous tools for all the rigs was $37.61 per day. One year after our campaign was initiated (1954), costs were reduced to $28.92 per day. In 1955, a decrease was also apparent, reducing the cost per day to $23.80 per rig per day. This is just one of the many programs adopted to try and regulate or even reduce operational costs. The increase in cost of equipment, as reflected in Fig. 2 and 4, does tend to raise operating expenses. In most cases, with proper purchasing control and effective rig maintenance, these expenses can be regulated and normal operating costs can be maintained.

Costs Depend On Size

Table 1 shows maintenance costs for rigs of the 5000, 8500, 12,000, and 15,000-ft depth classes. Costs are largely dependent upon the size or depth rating of the rig as follows:

Depth rating	5000′	8500′	12,000′	15,000′
Rated hp	450	750	1,350	1,620
Maintenance and labor cost	$441.79	$516.41	$618.71	$650.42
Cost per rated hp	$ 0.98	$ 0.69	$ 0.46	$ 0.40

It should be pointed out, that the average pump operating costs of this report do not reflect the increase in pump expense incurred by jet bit drilling and high pump pressures resulting from this operation. These mud pumps were not used to any great extent for jet drilling prior to 1953.

The 12,000-ft rig class reflects the upsurge in operating costs due to this procedure. In 1950, the cost of operating an 825-hp pump for normal drilling operations was $29.71 per day. This same pump took $57.80 per day to operate in 1955. True, some of the operating cost rise was due to the increase in charges for replacement parts, but the majority of this increase is due to the increase in horsepower input necessitated by jet bit drilling.

Miscellaneous Equipment Operating Expenses

The final group of costs appearing in this report consists of the remainder of expenses incurred during drilling procedures. These cover auxiliaries and accessories such as air compressors, electric equipment, blowout preventors, paint, hand tools, etc. As illustrated in Fig. 4, these costs constitute 8.82 per cent of the total operational expense. Closer examination of these costs reveals that general rig supplies (hand tools, wrenches, valves, drill pipe fittings, etc.) constitute approximately 60 per cent of the total costs.

While it is realized that this group (general rig supplies) should be high due to the excessive turnover in these items, Big Chief conducted a campaign to try to reduce this expenditure. In

This illustrates that expense per horsepower decreases with increased rig power capacity and shows an advantage for equipping rigs with greater than normal usable engine horsepower.

It might be well to point out that these maintenance costs are considered the result of good operation and maintenance practice. This practice includes the use of preventive maintenance, schedules, periodic inspections, on-the-job-training of crew members, planned and regulated lubrication, and up-to-date records on all operating machinery.

Acknowledgment

The author expresses appreciation to Big Chief Drilling Company for permission to publish these maintenance costs which were obtained from their files. Also, thanks go to T. W. G. Richardson, Tulsa area drilling engineer, Shell Oil Company, for his assistance in compiling and editing the report. ★ ★

New Integrated Oil Company

Birth of a new completely integrated oil company is underway. Agreement has been reached on terms of a plan to integrate Northwest Production Corporation, a subsidiary of Pacific Northwest Pipeline Corporation, and Western States Refining Company. Northwest Production now has six drilling rigs working on some 100,000 acres under lease in the San Juan Basin and other Rocky Mountain fields. Western States markets products through 121 stations in a six-state area.

OU Establishes Halliburton PE Chair

The Erle P. Halliburton chair in petroluem engineering, the first professorship of its kind at The University of Oklahoma, has been established.

The chair will honor Erle P. Halliburton, founder of the Halliburton Oil Well Cementing Company of Duncan. Halliburton now is chairman of the board of the corporation. Established in 1919, the firm now is engaged in oil well services on a world-wide basis.

Dr. Charles Gardner Dodd, formerly associate professor of chemistry at Lehigh University, has been chosen to fill the new Halliburton chair in petroleum engineering.

In a letter to President L. B. Meaders of the Halliburton Oil Well Cementing Company, University President George Cross said, "I think that this action on the part of your company represents a milestone in our efforts to improve the faculty in petroleum sciences at OU."

Dr. John M. Campbell, chairman of the school of petroleum engineering at OU, said, "We feel that this is a significant event. The interest of Halliburton and other companies, we believe, will continue to contribute to the quality of the petroleum engineering program at the university."

The Halliburton company's agreement will provide $6000 a year for three years to supplement regular university funds in paying the salary of the Halliburton professor. At least $4000 of the $6000 must be paid to the professor holding the Halliburton chair.

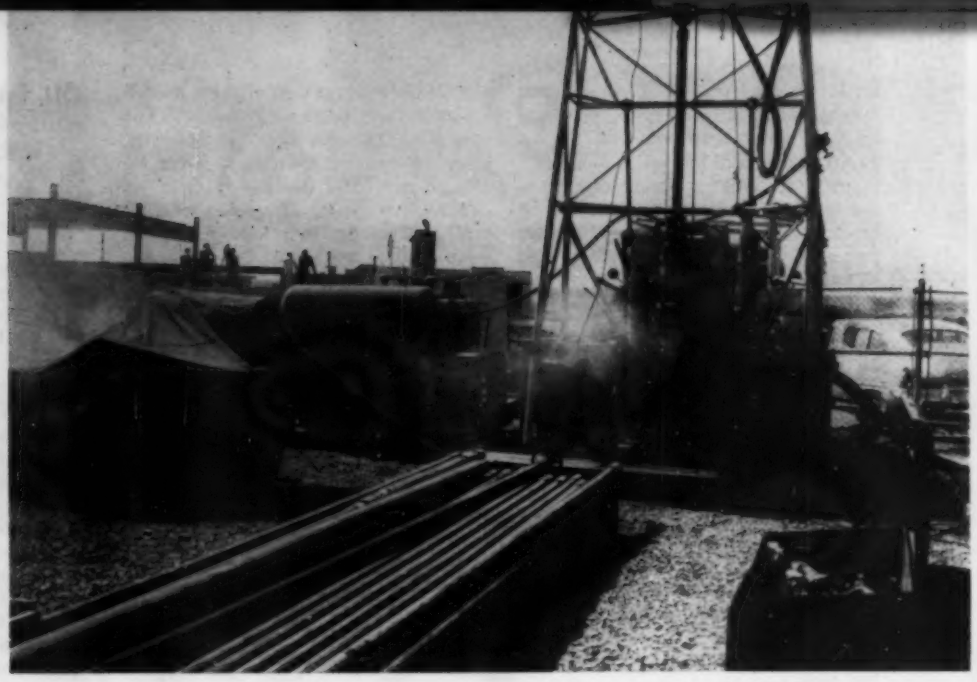
Dr. Dodd is well known throughout the oil industry. He was a research associate with the Continental Oil Company from 1952 to 1955. Prior to that he was senior physical chemist with the U. S. Bureau of Mines, and an assistant professor at Pennsylvania State College.

Dr. Dodd received his PhD in chemistry at the University of Michigan in 1948. He was awarded his MS at the same institution in 1945 and received the Bachelor of Science in chemical engineering at Rice Institute in 1940.

He is a member of the American Chemical Society, the Crystallog Society, the American Institute of Mining and Metallurgical Engineers, the Oklahoma Academy of Science, and the American Association of the Advancement of Science. He is listed in "American Men of Science."

Arabian Crude Production Up

Crude oil production in Saudi Arabia during August totaled 31,184,218 bbl, or an average of 1,005,943 bbl per calendar day, the Arabian American Oil Company has announced.



Air drilling test rig used to drill shallow wells to correlate laboratory research data with field tests on shutting off water zones and to gain more knowledge about the problem.

P 444.36

Research and field tests explore possible solutions to . . .

Shutting Off Water Zones In Air Drilling

Here is what's underway in the laboratories and field tests on a knotty problem. Developments look promising but no positive method available yet.

Wayne F. Hower, Joe Ramos, and Hugh J. Ayres
Halliburton Oil Well Cementing Company, Duncan, Oklahoma

EXCLUSIVE

THE main deterent to a rapid expansion of air drilling is the difficulties encountered when water producing zones are penetrated by the drilling bit. Almost every article written on the subject cites this trouble and states that, if an economical method of controlling the unwanted water can be developed, the use of air, gas, exhaust gas, and aerated muds will greatly increase.

Water has caused trouble in different ways. In some cases, there is only enough water present to dampen the cuttings. This often forms a mud that collects on the side of the hole and drill pipe above the bit. The resulting "slim" hole can stick the bit when a round trip is attempted. Greater flows of water are capable of causing other troubles and must be controlled before efficient air drilling becomes a reality.

Problem is different. Generally, shutting off water in an oil well is a common procedure. Many materials have been used that have been successful under certain conditions but it is usually conceded that the operation is relatively routine. Specifically, shutting off water in air drilled wells is another matter. There is no casing present that will aid in holding the blocking material in place. The hole size should not be reduced by the plugging agent and the seal must be permanent enough to withstand round trips and continual beating of the drill pipe.

Types of water zones. Time is also an important factor with an expensive drilling rig standing over the hole. This emphasizes the importance of being able to quickly and efficiently shut off the water.

In an effort to better understand the problem, it would be well to further classify water producing zones. Seeping or "weeping" zones that produce only small quantities of water are perhaps the hardest to control. This is the type of production that wets the cut-

tings enough to decrease hole size and subsequently stick the bit. In isolated cases, it has been possible to "dry up" such a zone by raising and lowering the bit while circulating with air. It is thought that this operation actually "muds off" the relatively low-pressure and tight sand. Addition of a controlled amount of water to the air stream has frequently alleviated this condition but the procedure is not always advisable and complicates drilling operations.

Zones that produce moderate flows of water can be handled in some areas but an accumulation of several of these zones can overload the hole with water. Where water swelling shales are present, the hole has been known to fill quickly with the expanded shale. This is a very serious condition and has been encountered frequently with air drilling. Air has been introduced to lime water and fresh water as a modification of air drilling. This variation is definitely of value in many weeping and moderate water producing zones but horizons that produce large quantities of water are still difficult or impossible to handle. The hole can become so full of water that it cannot be unloaded with the available supply of air.

Development of Sealers

Laboratory research was instigated in an effort to develop materials and methods of controlling all types and rates of water flow. Cores of varying permeability were first saturated with water and then treated with a variety of grouting solutions. For the most part, these agents are true solutions that react to form stiff gels or hard masses after being placed in the core. There are many grouting solutions available that have been used to successfully plug cores in laboratory tests against hydraulic pressures up to 2000 psi. Since a low cost material is desirable, research was concentrated on the cheaper chemicals. Other factors such as viscosity control, ease of handling, and control of the setting characteristics of the solutions were investigated.

Rig used in research. Laboratory research, however, is not everything and the small rotary rig shown in Fig. 1 was obtained to further study the problem. It was converted to an air drilling rig and used to drill a series of holes. After setting a short length of surface pipe, the wells were cored with a 4¾-in. bit in their entirety and the recovered cores of water producing sands were tested in the laboratory. The main object in mind was to develop a correlation between laboratory findings and actual applications in the well.

Water problem in tests. The water producing sands, so investigated in this series of tests, were all quite shallow

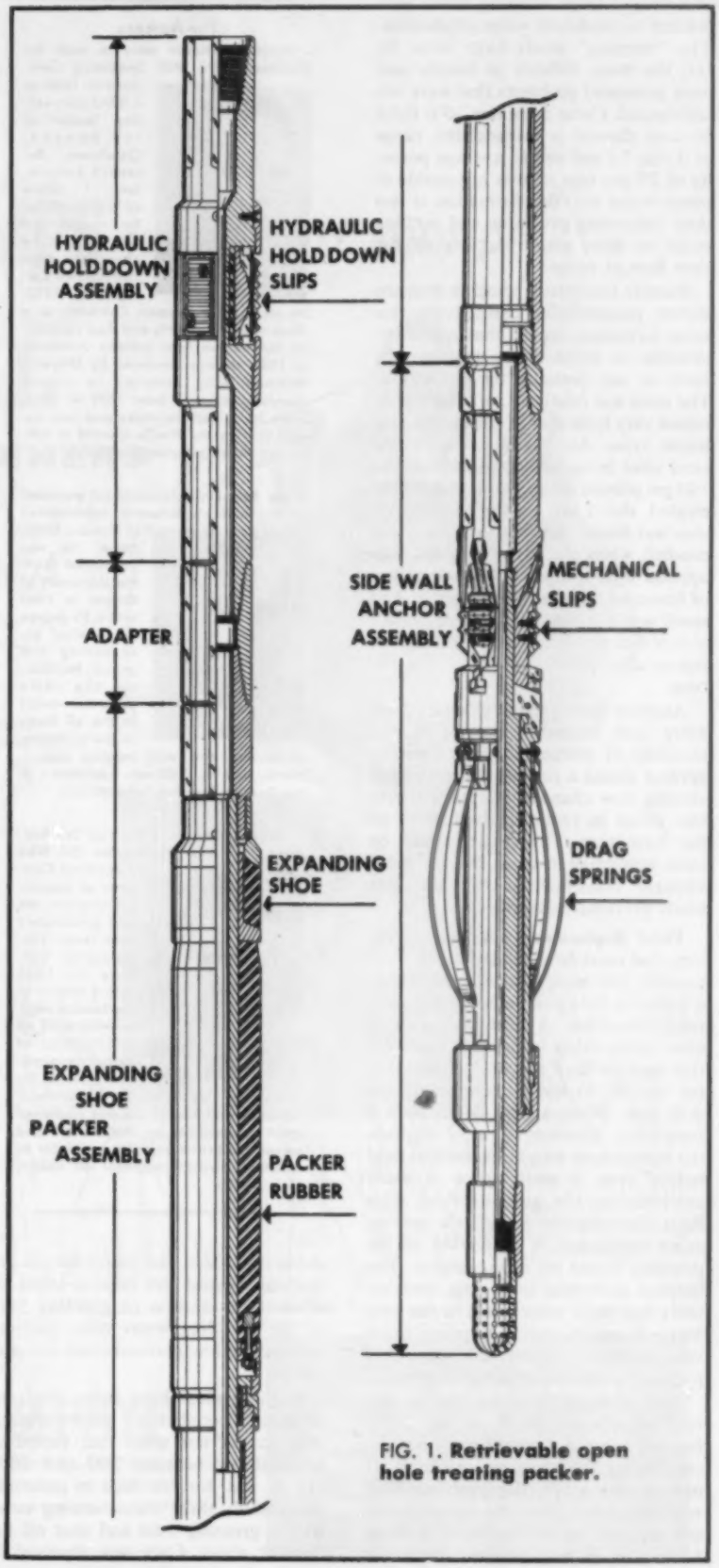


FIG. 1. **Retrievable open hole treating packer.**

and ranged from weeping water production to moderate water production. The "weeping" sands have been, by far, the most difficult to handle and have presented problems that were not anticipated. Cores from one 20-ft thick horizon showed a permeability range of 0.3 to 7.8 md and an average porosity of 27 per cent. It was impossible to pump water into this formation at less than fracturing pressures and nothing could be done about shutting off the slow flow of water.

Further laboratory research with the higher permeability cores from this same formation proved that it was impossible to force water through the cores at any pressure up to 100 psi. The sand was relatively soft and it contained very little clay of the montmorillonite type. An examination of the sand after being subjected to water at 100 psi proved that water had not penetrated the 1-in. length of core. It also was found that the sand face was crushed when the water pressure was applied thus forcing individual pieces of fine sand into the flow channels. The result was a drastic reduction of permeability that prevented the entrance of a measurable quantity of water into the core.

Another factor that influences fluid entry into permeable media is the elasticity of permeable rock. Pressure applied across a rock face can deform existing flow channels and have a definite effect in reducing fluid entry to the formation. This phase would be more applicable to sands that are more strongly consolidated than the soft sands previously described.

Fluid displacement. A final condition that must be considered is the resistance that must be overcome before a grouting fluid can enter a fluid saturated formation. A certain amount of momentum exists in the fluid reservoir that may or may not be compensated for by the hydraulic column in the drill pipe. When a fluid enters such a formation, however, it must displace the tremendous weight of residual fluid before even a small space is made available for the grouting fluid. This fluid displacement is difficult and an exact mathematical evaluation of the problem would be very complex. The findings here help to explain observations that have been made in the past where it was impossible to pump water into numerous formations that were producing definite volumes of water.

It is thought by many that to obtain an efficient block in the water bearing zones a fracture must not occur during the grouting operation. If one should occur, the grouting fluid will probably follow the fracture and not saturate all of the water bearing formation. It may be seen from the above discussion that many factors are working against the desired effect of efficient penetration of grouting fluid in the offending water zone, particularly where low permeabilities are prevalent.

High permeabilities help. Horizons of greater permeability were encountered in the test wells that varied in permeability between 300 and 3000 md. It was possible here to penetrate successfuily these water bearing sands with a grouting fluid and shut off the flow of water. Care was observed in holding pump pressures at a relatively low level to prevent the occurrence of a fracture. This resulted in some very low pumping rates that generally fell in the range of 0.05 to 0.10 bbl per minute.

Core analysis of the successfully treated zones proved that a wide range of permeability existed. In an attempt to assure the penetration of grouting fluid in every part of the permeable formation, fluid loss control material was added at strategic times. This procedure seemed to be of value in view of the successful results that were obtained.

Side wall cores taken. Side wall cores were taken of several treated formations and excellent saturation of the recovered cores with grouting material was observed where good permeabilities existed. One relatively tight formation showed about ½ in. penetration of grouting fluid and it appeared to be effective in blocking that particular water flow.

Types of grouting fluids. Previous mention has been made concerning the different types of grouting fluids that are available. Since laboratory tests with many types were successful in plugging cores, the above tests in the well were performed with the cheapest material available. It has a relatively low viscosity, about 10 centipoises, and it sets to form a stiff gel. Gels of this type have been used in many other grouting operations very successfully and their relatively soft set is a safety factor, as compared to hard setting materials, when used in a well. Low viscosity materials also are highly desirable for fluid grouting as high fluid flow in permeable formations is directly associated with low viscosity materials. However, even at the relatively low viscosity of 10 centipoises, there was a considerable greater resistance to flow of this grouting material into the formation when compared to the flow of water. This is to be expected but it is being emphasized to illustrate the reason for the very low injection rates that were observed in successfully plugging water bearing zones in the test wells.

Correlation of tests. One very gratifying fact that was derived from this phase of research was the very close correlation between laboratory tests and well applications. Core analysis and fluid penetration tests accurately predicted the results that were later obtained in the experimental wells.

Use of cement. Field applications have shown varying degrees of success. Not enough data has been accumulated for an overall evaluation but considerable difficulty has been noted in every area. It has been reported that oil-cement slurries have been successfully

The Authors

Wayne F. Hower went to work for Halliburton Oil Well Cementing Company in 1946 as a laboratory section leader at the Duncan, Oklahoma, Research Laboratory. A native of Warren, Ohio, he received a BA degree in chemistry from Youngstown College in 1937. He worked for Koppers Company as a chemist for 18 months and then received an MA degree from Indiana University in 1939. He was employed by Sherwin-Williams Paint Company in organic chemistry research from 1939 to 1943, when he joined the Navy and saw active duty in the Pacific aboard a submarine as an electronics officer.

Joe Ramos is a development engineer in Halliburton's Research Laboratories at Duncan, Oklahoma. He was graduated from the University of Kansas in 1940 with a BS degree in chemical engineering and joined Halliburton the same year. He worked in the oil fields in the acidizing, cementing, and well logging departments, and in 1943 was transferred to the Duncan Research Laboratories.

Hugh J. Ayres is in the Tool Development Section of Halliburton Oil Well Cementing Company at Duncan, Oklahoma. He was graduated from Texas Technological College in 1948 with a degree in mechanical engineering after an interruption of his undergraduate studies by military service in the U. S. Air Force during World War II. He was employed upon graduation by Halliburton and served as district engineer and later as assistant division engineer at Hobbs, New Mexico.

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applied to shut off water in zones of high permeability, but it is felt that the application of materials of this type may be limited to specific conditions or areas. Fractures usually occur when cement slurries are used and the sealing effect may be localized. Water that is being produced from inherent fractures, however, can be successfully blocked by this procedure.

Swelling shales. Another condition that further complicates this problem is the close proximity of water swelling shales to many water zones. Packers usually cannot be set efficiently in zones of this type and, if the grouting fluid cannot be isolated below a packer, past experience has shown that it will enter the shale section in preference to the water zone. In addition, it is very difficult to obtain a clean well when shale continues to fall into the hole. Partial plugging of the water zone can occur and efficient penetration of the grouting fluid into the formation would be impossible, thus defeating the aim of effectively shutting off the water.

Isolating zone. It has developed that one of the major problems of water shut-off in air or gas-drilled holes is the confinement of the remedial or plugging materials. This is necessary since there is usually no means of determining the pressures at which the other exposed formations will take fluid relative to the formation to be treated. To assure proper placement, it is imperative that the grouting material be directed to the desired entry point. Actual requirements will widely vary and are dependent on how readily the water-productive zone will accept fluid and the nature of the formations above the point of water entry.

If the zone to be squeezed does not readily accept the fluid, it is necessary sometimes to provide means other than drill pipe weight to prevent unseating the packer due to pump pressures.

Upon certain occasions, it will be desirable to set the confining packer in a shale section above the source of the water. This is usually a hazardous pursuit under the best circumstances. If the shale tends to deteriorate rapidly upon contact with water, a packer seat may not be available by the time the tool is on bottom.

Packer developed. An open hole retrievable treating packer has been developed for this purpose. The tool embodies no great departure from established practice for anchorless casing packers. The mechanical or support slips are provided with sufficient horizontal over-travel to permit engagement in oversize or enlarged hole. This portion is more familiarly known as side wall anchor and has been used extensively for off-bottom drill stem testing. The packing element is a rubber sleeve of the expanding shoe type that has been proven by years of drill stem test experience. A hydraulically or pressure activated hold down is incorporated in the tool to prevent unseating the packer with excessive pressure differential.

Sufficient field experience has been gained to show that the open hole treating packer will serve adequately to isolate a water producing zone if the drilled hole is not susceptible to rapid enlargement.

Developments look promising. Much has been learned concerning this problem and, although knowledge has been gained, it is strongly emphasized that a solution for all known conditions will be very difficult to obtain. It appears that materials and tools are available that show promise in successfully controlling water where it is possible to pump them into the formation. The weeping zones have not been successfully treated and considerable difficulty can be expected where water swelling shales occur close to any type of water producing zone. It is an extremely difficult problem, but research is continuing on new ideas, new materials, and new tools in a comprehensive effort to find an economical solution. ★

Drilling Contractors Stress Industry Teamwork and Unity

INDUSTRY teamwork and unity, world oil, new drilling fluids, and the turbodrill will be the main topics for discussion at the sixteenth annual convention of the American Association of Oilwell Drilling Contractors. The group, expected to number above 1200, will converge in Fort Worth, Texas, for a three-day meeting beginning October 7. Main convention site is the Texas Hotel.

Speakers, representing major and independent producing companies, contractors, research organizations, and government, will discuss subjects ranging from technical studies to international oil economics.

Keynote speaker is W. Randolph Burgess, Undersecretary of the Treasury for Monetary Affairs and former president of the American Bankers Association. Burgess will address the contractors' group at the closing banquet on October 9.

Six oil industry spokesmen will speak during the course of the meeting.

The opening address at the first general session, Monday afternoon, October 8, will be delivered by E. Dale Mount, who has served as president of AAODC for the 1955-56 term.

"World Oil, the Domestic Oil Producer's Position" is the subject chosen by Lt. Gen. E. O. Thompson, Texas Railroad Commissioner, who will also speak Monday.

Oil industry cooperation is the theme of A. W. Thompson's talk Tuesday morning on "API-AAODC Teamwork — Key to Greater Progress." Thompson, a past president of AAODC, is vice president for production of the American Petroleum Institute.

Speaking for independent producers, Robert L. Wood, president of the Independent Petroleum Association of America, will talk Tuesday afternoon on "In Good Times and Bad — Down We Go Together."

Dale Mount
AAODC President

Two technical papers on drilling engineering developments will be read at the Tuesday general sessions.

J. L. Lummus, Stanolind Oil and Gas Company, Tulsa, will discuss "Development and Application of a New Oil-Base Drilling Fluid," at the morning meeting.

"Turbodrills — Past and Present," a timely subject of interest among oil men, will be reviewed Tuesday afternoon by J. H. Thacher, Jr., vice president of California Research Corporation, San Francisco. Co-author of the paper is W. R. Postlewaite, mechanical engineer, Standard Oil Company of California.

Convention chairman, C. J. Davidson, who is president of Davidson Drilling Company, Fort Worth, will preside Tuesday evening at the banquet which will climax the contractor's meeting. ★ ★ ★

Lithology of the Mesaverde sediments in the San Juan Basin determined by . . .

Interpretation of Radioactivity Logs In Gas-Drilled Wells

Procedure applicable in similar sediments to establish: (1) porosity, (2) formation content, and (3) per cent of fluid

Dan H. McLendon
Lane-Wells Company, Dallas, Texas

LITHOLOGY of the Mesaverde sediments of the San Juan Basin in northwestern New Mexico can be determined within reasonable limits by the proper interpretation of radioactivity logs in gas-drilled wells. This procedure represents a new approach and is based on a careful study of the correlation between core analysis and radioactivity logs of key wells in the area.

Although the interpretation presented here applies specifically to the Mesaverde section, the procedure by which these interpretations are made may be applied successfully in other areas where gas-drilled wells penetrate sand-shale sediments.

Porosity of sands can be determined within reasonable limits and a scale is provided for this purpose. Since the neutron measures total fluid content in the formation, by proper use of nomograph, the formation content can be determined. Also, a scale is presented for determining the per cent of fluid in the various porosity ranges which is useful in computing reserves.

Gas drilling in brief. As a result of the combined efforts of many operators and service company personnel, a technique has been developed to drill gas wells more efficiently in certain areas of the Rocky Mountain region. This technique is referred to as gas or air drilling and numerous articles have been written covering the details. Briefly, gas or air, under pressure, is introduced down the drill pipe, returned through the annulus and discharged or flared a safe distance from the rig. Either natural gas or exhaust gas may be used, and compressors are available on a rental basis to provide the necessary pressure. The increased efficiency is due to longer bit life and increased penetration rates over fluid drilling. In addition, the water supply problem is eliminated along with that of lost returns. The one serious disadvantage of gas or air drilling at the present time is the detrimental effect of free formation fluid which balls up the bit and causes stuck pipe. When this happens, the well is converted to fluid drilling until a protective string is set. Then, it may or may not be reconverted to gas or air. Research is being conducted in an attempt to solve this problem.

Why method is used. From the foregoing it is apparent that only in arid areas can gas or air drilling be successfully used under the present state of development. One of these areas is in the San Juan Basin of northwestern New Mexico. In drilling for gas in the Basin, lost circulation is very costly and difficult to overcome with mud. Add to this the availability of unlimited quantities of gas at 500 psi line pressure at the well and it is then easily understood why the lost circulation zones, at least, are gas-drilled.

Drilling practices. One of the most difficult lost circulation zones en-

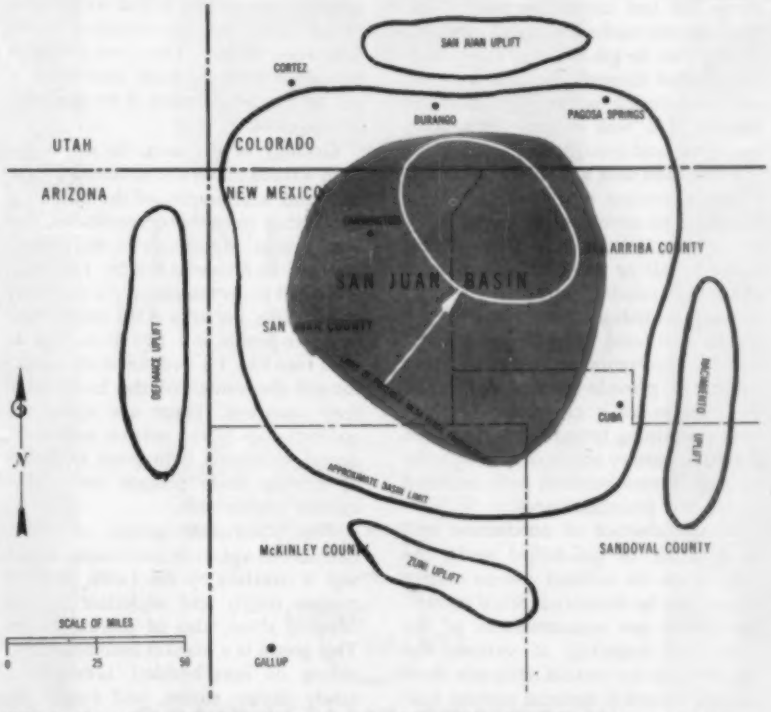

FIG. 1. **San Juan Basin of northwest New Mexico.** The Mesaverde group underlies the shaded area shown above and outcrops at the boundaries of this area. Approximate limits of Mesaverde gas production within the Basin are indicated.

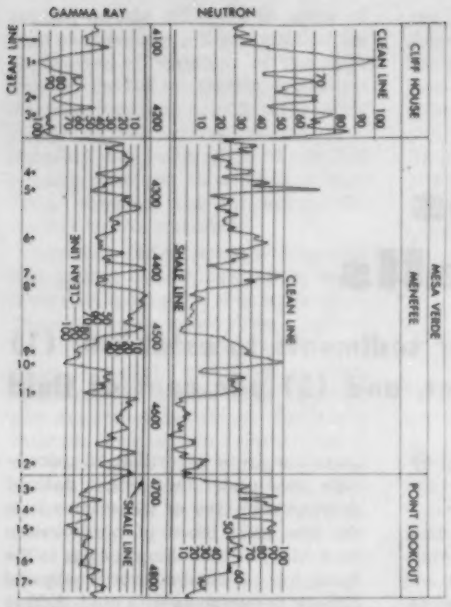

FIG. 2. **Mesaverde group,** of upper Cretaceous age, consists of the Cliff House, Menefee, and Point Lookout formations.

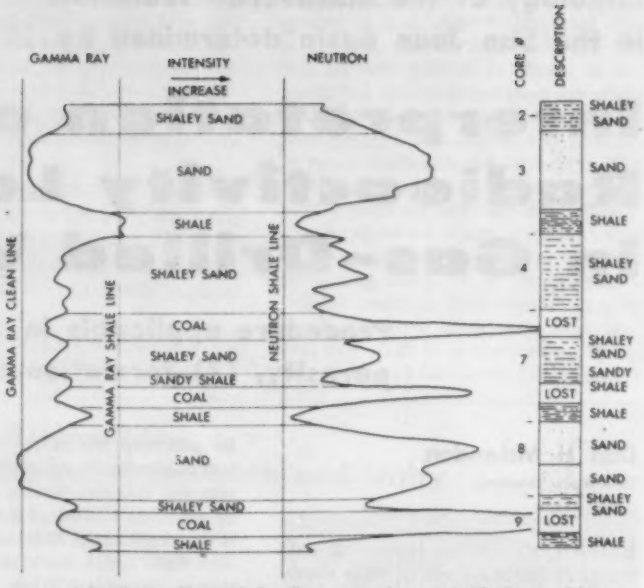

FIG. 3. **Radioactivity log,** core log and lithology of Mesaverde group. The radioactivity log is from sections of an actual log run in the San Juan Basin.

countered in any San Juan Basin well is immediately above the Mesaverde section, a blanket sand zone containing tremendous gas reserves. In a Mesaverde well, it is standard practice to drill with mud down to a point near the top of the Mesaverde section (just above the lost circulation zone,) cement an intermediate string of pipe and change over to gas drilling. The hole is then drilled through the pay, logs are run, and casing is run dry, then cemented. The well is then perforated, fractured, and brought in.

Formation data a problem. As usual, a new technique introduces problems that must be solved before its full benefit can be realized. One of the problems posed by air or gas drilling is that of obtaining reliable information concerning formations penetrated by the bit. In drill holes filled with a conductive fluid, conventional electrical curves suffice to provide needed data. The fluid serves as a conductor between beds containing formation waters, and a natural battery action occurs with the flow of current between beds recorded as the self potential curve.

In the absence of conductive well fluid in air or gas-drilled wells, the formations are isolated and no battery action can be measured. Since resistivity curves are measurements of the formation resistivity at various distances from the current electrode, none can be recorded because current cannot be introduced into the formations except by induction. Since the use of self potential and conventional resistivity curves are not applicable in air or gas-drilled wells, subsurface data are obtained by those devices which obtain temperature, caliper, induction conductivity, and radioactivity measurements plus core and bit-cutting information. This discussion will be limited to the interpretation of radioactivity logs in gas-drilled wells completed in the Mesaverde section of the San Juan Basin. This interpretation technique may be used elsewhere in gas or air-drilled wells if similar conditions exist.

Geology of the area. So much has been written about the structure, lithology, and stratigraphy of the San Juan Basin that only those conditions that are of most importance in this discussion will be reviewed briefly. The basin is located in northwestern New Mexico and covers an area 150 miles from north to south and 120 from east to west (see Fig. 1.) Sediments dip gently toward the center of the basin from their outcrops. There are many unconformaties in the marine and continental sediments with great thickness of marine shale present for hydrocarbon source beds.

The Mesaverde group, of upper Cretaceous age, is of continental origin and is overlain by the Lewis shale of marine origin and underlain by the Mancos shale, also of marine origin. This group is a blanket formation consisting of interbedded sandstones, sandy shales, shales, and coals. The group consists of three members: (1) Cliff House (predominably sandstone) top member; (2) Menefee (interbedded sandstone, shale, shaly sand, and coal) middle member, and (3) Point Lookout (sandstone, shaly sandstone) bottom member (see Fig. 2.) Transgressive shore lines during the time of deposition are responsible for the interbedded nature of these near-shore sediments. The map in Fig. 1 indicates productive limits of the Mesaverde group.

Sediments of the Mesaverde section may be classified as graywackes which accounts for the fair porosity, through relatively low, irregular permeabilities of the reservoir sands. Poor sorting by grain size and shape is partly responsible for the latter characteristic. There are varying amounts of shale and clay material in the sands and, as they increase, the porosity and permeability of the sands suffer. Also, the presence of more or less amounts of shale and clay may be detected by the gamma ray curve, and all formations registering low radioactivity are relatively clean. Conveniently, there is no limestone, dolomite, or anhydrite in the Mesaverde section to confuse with a clean, gas-bearing sandstone.

Interpretation of Radioactivity Curves

Because the gamma ray curve is unaffected by the presence of casing, mud, or gas, and measures only the natural gamma radiation from the formation, it is an invaluable aid in correlating gas drilled, fluid drilled, cased, or uncased wells. The neutron, however, measures hydrogen (or fluid) saturation and is influenced by all hydrogen in the proximity of the instrument whether it is in the form of

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natural formation fluid, gas, oil, mud filtrate, drilling fluid, or chemically bound water. High fluid saturation is indicated by a low neutron response (curve approaches the shale line) and low fluid saturation by a high response (far to the right.) In mud-drilling through a gas sand, the drilling mud filtrate invades the porous and permeable zones, displacing all but the residual gas away from the well bore. Under these circumstances a much greater fluid saturation will be indicated than was present before drilling. In the case of a gas drilled well, however, since no filtrate has entered the formation, the fluid saturation will not be affected by the formations having been penetrated by the bit. Mesaverde wells are normally drilled with 450 psi gas, and since the formation pressure is approximately 1200 psi, the wells are continually gassing and no drilling gas enters the formation due to the pressure differential.

Determination of lithology. Of prime importance in interpreting any radioactivity log is the determination of lithology. In the Mesaverde group it is necessary to differentiate between coals, sandstones, sandy shales, and shales. The log shown in Fig. 3 is composed of sections from an actual radioactivity log in the San Juan Basin. Also shown are the core log and lithology. Both gamma ray and neutron curves are recorded with increase in intensity to the right. On the gamma ray curve, clean sands show lowest intensity, shaly sands and coals are somewhat higher, and shales show highest intensity. On the neutron curve, coals show the highest intensity, clean sands a little lower, sandy shales still lower, and shales show the lowest intensity.

Shale contains much chemically bound water which influences the neutron. Frequently, coals show high gamma ray intensity and might be confused with sandy shales or shales, but the neutron correctly identifies them by exhibiting a high intensity. (Practically all coal cores are lost because the coal is so highly fractured.) Since the coals are highly fractured and brittle, pieces slough into the hole when drilled, leaving a large cavity (piles of coal in small pieces can be seen around the discharge flares.) Many of the fragments are larger than bit cutting size indicating that they sloughed after being drilled. When the radio activity survey is run, the neutron response in the enlarged hole opposite the coal is of high intensity which is the normal response due to the cavity being filled with gas.

Quantitative interpretation. For a quantitative study, two Phillips Petroleum Company wells that cored the Mesaverde section with gas circulation were chosen. These wells are the Phillips 32-8 Mesa 2-29, and Phillips 30-6 Mesa 5-35. On the Mesa 2-29 well, in addition to the combination radioactivity log, the lithology of cores with core analysis consisting of porosity, permeability, and water per cent of porosity (or water saturation) were available. On the Mesa 5-35 a combination radioactivity log, a conductivity induction log, temperature survey, lithology and core analysis consisting of porosity, permeability, and water per cent of porosity were available. Figs. 4 and 5 show a comparison of the radioactivity survey with porosity and water per cent of porosity. Superimposed on the neutron curve is a reversed gamma ray which was found helpful in accurate correlation work. Permeability is so eratic that no benefit has been gained from its study. For this reason it is not shown.

Neutron response. At first glance it is noticed that the neutron curve responds with a high intensity in the more porous sections. Water saturation in these highly porous zones is quite low, as expected. It is further noted that the core porosity plot and water saturation plot are almost mirror images; that is, low porosity matches high water saturation and high porosity matches low water saturation. Since interstitial water in the core samples is retained by capillarity during gravity segregation, sands having low porosity

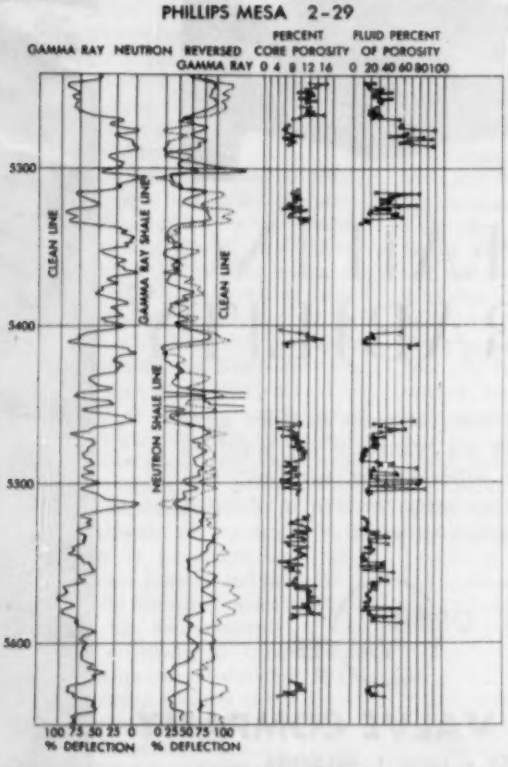

FIG. 4. **Porosity and fluid** saturation compared to radioactivity log in Phillips Mesa 2-29.

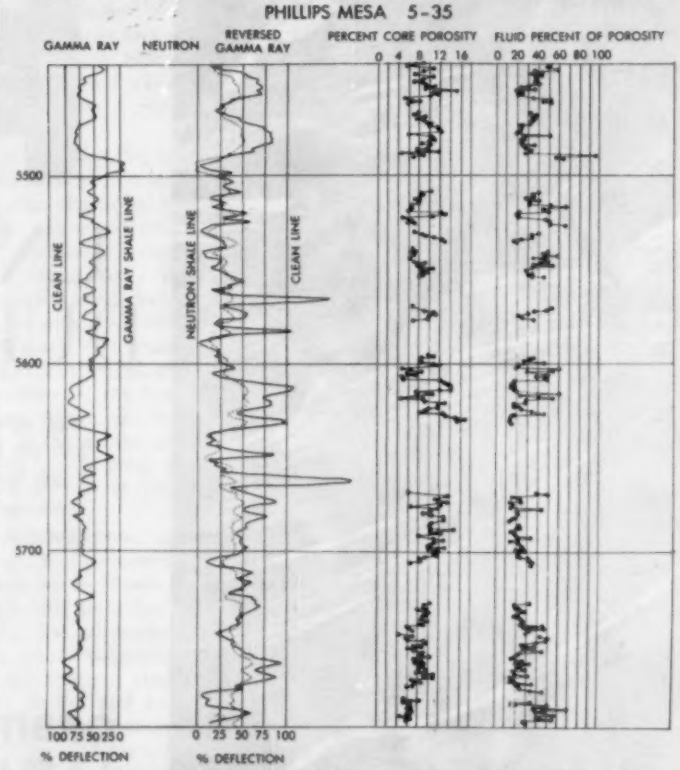

FIG. 5. **Porosity and fluid** saturation compared to radioactivity log of Phillips Mesa 5-35.

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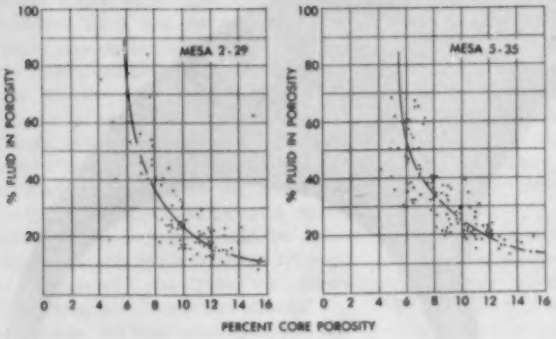
FIG. 6. **Core porosity** vs water saturation for the two Phillips wells.



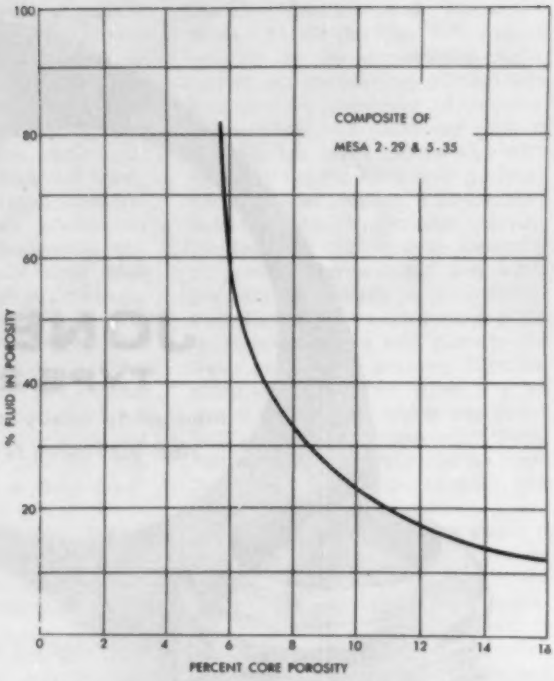


FIG. 7. **Composite curve** (or average plot) of Phillips Mesa 2-29 and Mesa 5-35, showing porosity vs water saturation, based on data taken from Fig. 6.

and low permeability are characterized by relatively smaller capillaries which have higher capillary attraction for water, thus retaining a higher per cent of water. This will explain the neutron response. Of interest is Fig. 6 which is a plot of core porosity vs water saturation for each well. Fig. 7 is an average of the two curves. Its use will be discussed later.

Porosity and neutron deflections. In order to determine if a relationship exists between neutron deflections and core porosity, a plot of the per cent neutron deflections as abscissas and the core porosities as ordinates was made on linear paper (Figs. 8 and 9.) Since a neutron zero was not available a shale line and a clean line were drawn on each log for reference. The per cent neutron deflections were measured from the shale line. This line was drawn through the average of the minimum deflections in sand zones. Since, in some localities, the Cliff House differs somewhat lithologically from the remainder of the section a separate clean line might be necessary for this upper member (see Fig. 2.) A common shale line was used throughout the entire section, however.

In drawing the clean line, care was exercised to exclude coal beds. As previously shown, these exhibit higher neutron deflections than clean, gas-bearing sands, and to establish an erroneous clean line would introduce considerable error.

A very definite trend can be observed on the point plots. Since the two neutron logs were run at different sensitivities, only by a per cent deflection plot could the two resulting curves be compared. Fig. 10 shows the two resulting curves plotted on semi-log paper. The fluid per cent of porosity read from Fig. 7 is scaled on the right margin for the appropriate porosities. An average of the two curves is shown. These sandstones contained only dry gas and fluid that was retained by capillarity. There are zones in the Mesaverde, however, that carry wet gas and yield an appreciable amount of distillate. Also, in some areas there are zones carrying producible water. Distillate, water, or oil increases the fluid saturation of sand and causes a much lower neutron intensity than if the same zone were dry.

By applying a neutron-derived porosity scale, a lower-than-actual porosity is indicated in wet sections. For

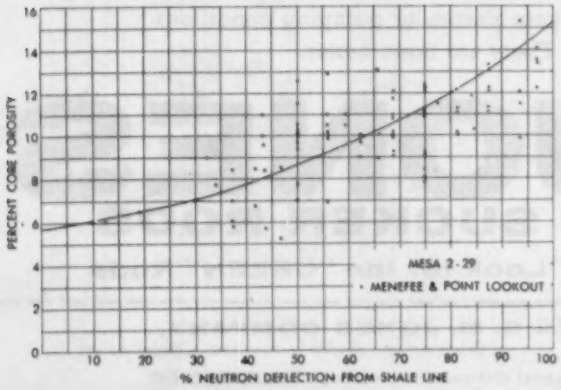


FIG. 8. **Porosity-neutron deflection** relationship for the Menefee and Point Lookout formations in the Phillips Mesa 2-29.

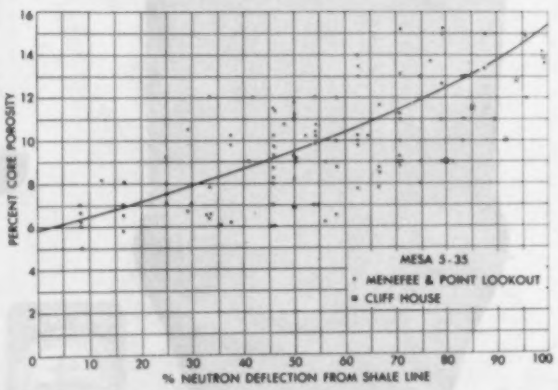


FIG. 9. **Per cent neutron deflection** vs porosity for the Mesaverde group in the Mesa 5-35.

this reason, the neutron is not reliable for porosity determination in these gas wells. Its usefulness is limited to the determination of total fluid present which is a combination of interstitial fluid and chemically bound water.

Fluid saturation. The fluid saturation of a rock sample is the ratio of the amount of fluid actually present to the amount possible in the sample. This is a relative value but when multiplied by the porosity of the sample the product becomes a finite measure of the fluid present. For example, a cubic foot of rock having 10 per cent porosity and 25 per cent water saturation contains 0.025 cu ft of water ($0.10 \times 0.25 = 0.025$.) This interstitial water plus any that is chemically bound in the formation influences the neutron deflection. (See Fig. 7.)

By simply multiplying porosity by the fluid saturation for that porosity at several points, the range is from a low of 0.0192 for a porosity of 16 per cent to 0.0360 for 6 per cent porosity. A plot of per cent neutron deflection from Fig. 10 vs total fluid thus computed is shown in Fig. 11. This relationship holds for gas-bearing sands only. Those containing producible fluids will exhibit much higher fluid saturation with resulting lower neutron deflection.

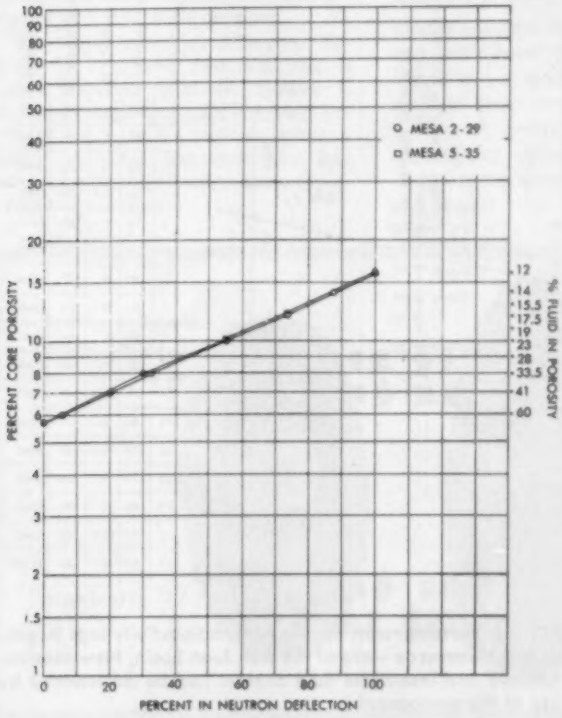
The curve in Fig. 11 confirms that the cleaner gas-bearing sands contain considerably less interstitial fluid than the shaly gas-bearing sands. The shaley sands contain chemically bound water not present in the clean sands which increases the contrast of content as indicated by the neutron.

Determining porosity. For possible porosity determination it was then decided to investigate the use of the gamma ray. After a very careful correlation of the core porosity plot with the combination radioactivity log, the per cent gamma ray deflections measured from the shale line were plotted as abscissas vs core porosities as ordinates on linear paper. As in the case of the neutron curve, extreme care was taken to draw the shale line through the average maximum deflections in the cleanest sands. A separate clean line for the Cliff House might be necessary. Figs. 12 and 13 are the plots for the two Mesa wells. Again, a trend is apparent, but in this case the fluid in the porosity has no effect on the deflection. The resulting curves best describing the scattering of points were then plotted on semi-log paper for comparison (Fig. 14.) A porosity calibration scale made from the average of the two curves is shown.

In order to use the gamma-ray porosity scale, it is necessary to establish shale and clean lines as described above, fit the appropriate limits of the scale to those on the log and scale the log for porosity directly. (An alternate method is to draw per cent lines which are translatable to porosity by using the nomograph, Fig. 15.) Usually 9.5 to 10 per cent porosity is considered net pay, all below this percentage being considered non-contributory. A vertical line through the critical porosity separates the pay on the left from the non-pay on the right. The net feet of pay can thus be counted. An average porosity might then be determined by averaging the porosity values. Using the average porosity, refer to Fig. 7 to determine the fluid per cent of porosity which is water saturation for use in reserve calculations.

Interstitial fluid. Refer to Fig. 15 for a nomographic interpretation of the log shown in Fig. 2. The first scale is the per cent gamma ray deflection (plus porosity from Fig. 14); the second scale is per cent neutron deflection (plus total fluid present from Fig. 11); the third scale is the interstitial fluid or gas. By reading the per cent deflections of both gamma ray and neutron at a given depth and connecting these values on the nomograph, and then extending the line to the third scale, the interstitial fluid can be determined. Also by use of the first scale, porosity of the zone is determined. The table of data contains values read from the log in Fig. 2 with porosity and formation fluid determined by nomographic solution. Point 17 is fluid bearing, and characteristically, the lower Point Lookout is waterbearing. For completion purposes, the gas-water transition zone may be placed at a point between points 16 and 17 on the log.

Applicable to other areas. Based on this study we have concluded that the lithology of the Mesaverde sediments can be determined by proper interpretation of radioactivity logs in gas



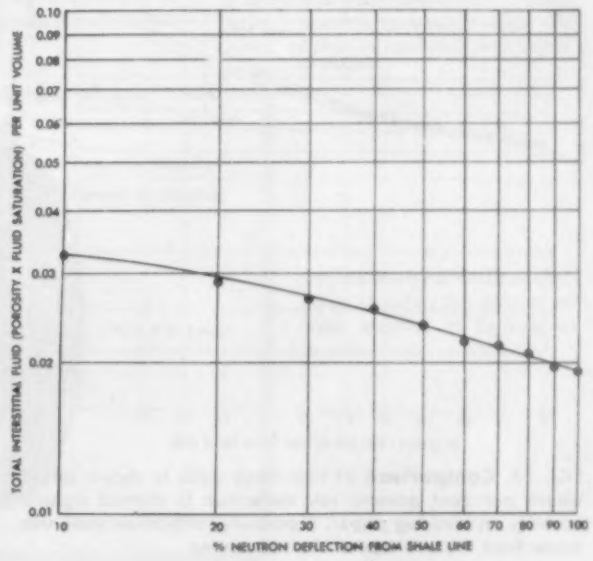


FIG. 10. (left) **Plotted on semi-log paper** are the two curves of Figs 8 and 9. Fluid per cent of porosity taken from Fig. 7 is scaled on the right margin. FIG. 11. (Below) **Cleaner gas bearing sands** contain less interstitial fluid than shaly gas bearing sands is confirmed in this plot of total fluid vs per cent neutron deflection from the shale line.

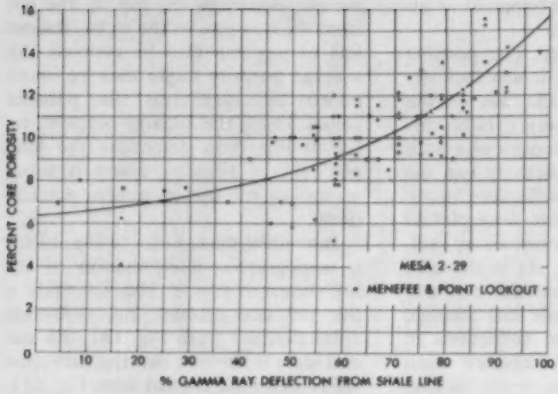


FIG. 12. **Gamma ray relation** to porosity plotted in per cent deflection from the shale line for the Mesa 2-29.

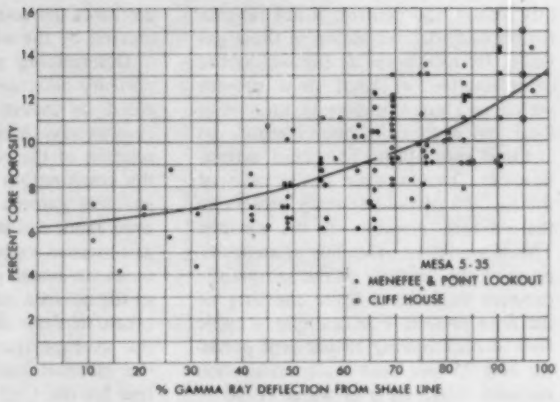


FIG. 13. **Through the Mesaverde group** of the Mesa 5-35 well, porosity vs gamma ray deflection from the shale line shows a trend on which fluid has no effect.

drilled wells. The porosity of the sands can be determined within reasonable limits and a scale is provided for this purpose. Since the neutron measures total fluid present in the formation, by proper use of a nomograph the formation content is determined. Also a scale is provided for determining the per cent of fluid in the various porosity ranges which is useful in computing reserves. Even though these scales and nomograph apply only to the Mesaverde group of the San Juan Basin, the procedure by which they were made may be successfully used with data from other areas where gas drilled wells penetrate sand-shale sediments.

The author wishes to acknowledge the assistance of Stanley G. Bendorf, consultant, Dallas, Texas, in the preparation of this material, and also to express appreciation to the Phillips Petroleum Company for release of logs and core analysis.

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Editor's Acknowledgment

This study, originally titled "Radioactivity Log Interpretation in Gas Drilled Mesaverde Wells of the San Juan Basin, New Mexico," appears in the current Fourth Quarter Issue of *"Tomorrow's Tools — Today,"* published by Lane-Wells Company, Los Angeles, California. ★ ★ ★

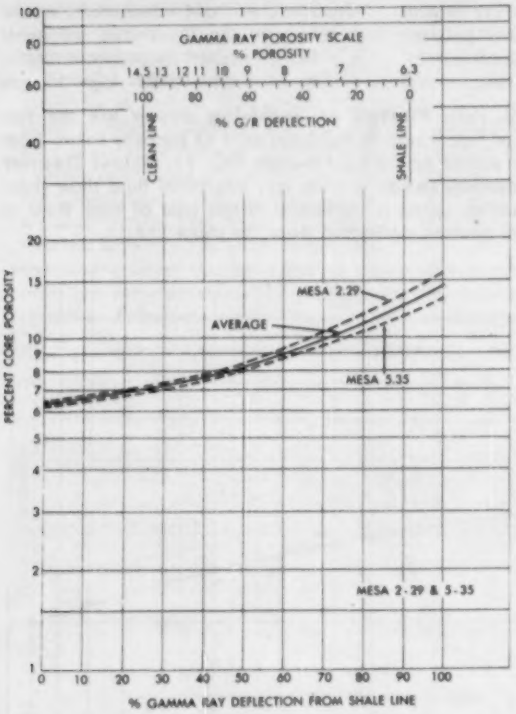
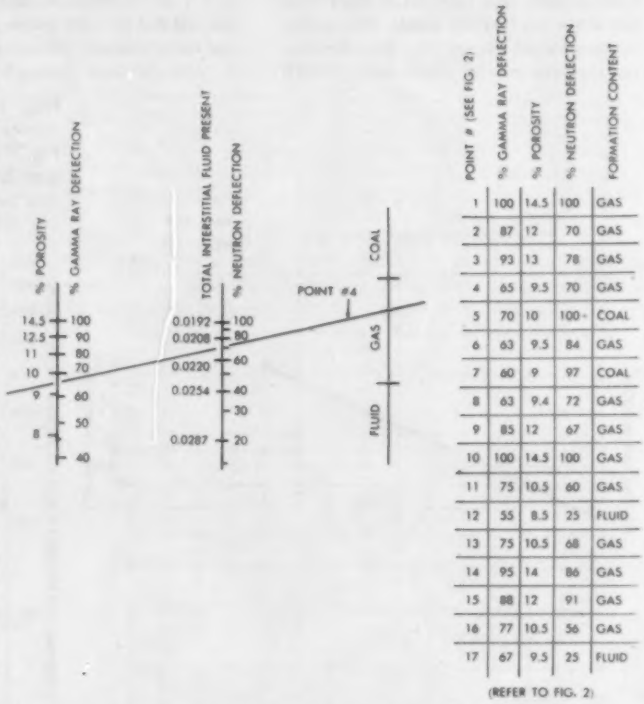


FIG. 14. **Comparison** of two Mesa wells is shown above where per cent gamma ray deflection is plotted against porosity on semi-log paper. A porosity calibration scale was made from the average of the two curves.



POINT # (SEE FIG. 2)	% GAMMA RAY DEFLECTION	% POROSITY	% NEUTRON DEFLECTION	FORMATION CONTENT
1	100	14.5	100	GAS
2	87	12	70	GAS
3	93	13	78	GAS
4	65	9.5	70	GAS
5	70	10	100+	COAL
6	63	9.5	84	GAS
7	60	9	97	COAL
8	63	9.4	72	GAS
9	85	12	67	GAS
10	100	14.5	100	GAS
11	75	10.5	60	GAS
12	55	8.5	25	FLUID
13	75	10.5	68	GAS
14	95	14	86	GAS
15	88	12	91	GAS
16	77	10.5	56	GAS
17	67	9.5	25	FLUID

FIG. 15. **Nomograph** for use with radioactivity logs in gas-drilled Mesaverde wells of the San Juan Basin, New Mexico. Porosity and interstitial fluid content can be determined by use of this nomograph.

Hydraulic Couplings And Torque Converters In Big Rig Drives

EXCLUSIVE

Types and operation of hydraulic drives and their application to large rig transmissions. Comparison is made of the use of couplings and torque converters on the drawworks and mud pumps.

Ross W. Colebrook,
Development Engineer, The National Supply Co., Houston, Texas

HYDRAULIC drives are used on drilling rigs to lower the cost of drilling. They do this by saving time, reducing repair bills on the engines and drilling machinery, and by enabling the rig to better handle emergencies.

There are two types of hydraulic drives designed to transmit the main power on drilling rigs. These are hydraulic couplings and torque converters. They are similar in the theory of operation, even though they act quite differently in use.

The engine's power is used to turn a large centrifugal pump in both a hydraulic coupling and a torque converter. In both types, the output shaft is driven by a turbine. The pump and turbine are called the impeller and the runner in a hydraulic coupling.

The basic physical difference between a hydraulic coupling and a torque converter is in the number of bladed parts. A hydraulic coupling has only a pump and a turbine, while a torque converter has these plus stationary guide blades and, in some types, additional turbines.

How They Work

The rotating pump blades convert the engine's power to kinetic energy in a rushing stream of oil. This stream of oil flows from the pump through the turbine, driving it like a water wheel. In a hydraulic coupling, the oil then flows back into the pump to complete the power transmitting system. This oil path is shown in Fig. 1.

In a torque converter, the oil leaving the turbine must flow through the stationary blades and additional turbines, if any, before re-entering the pump to start the cycle over. The stationary blades in a torque converter act on the oil stream like a fulcrum acts on a lever. The blades change the direction of the oil in such a way that the turbine runs slower than the pump and pulls hard against heavy loads. Fig. 2 is a diagram of the oil flow in a single stage torque converter.

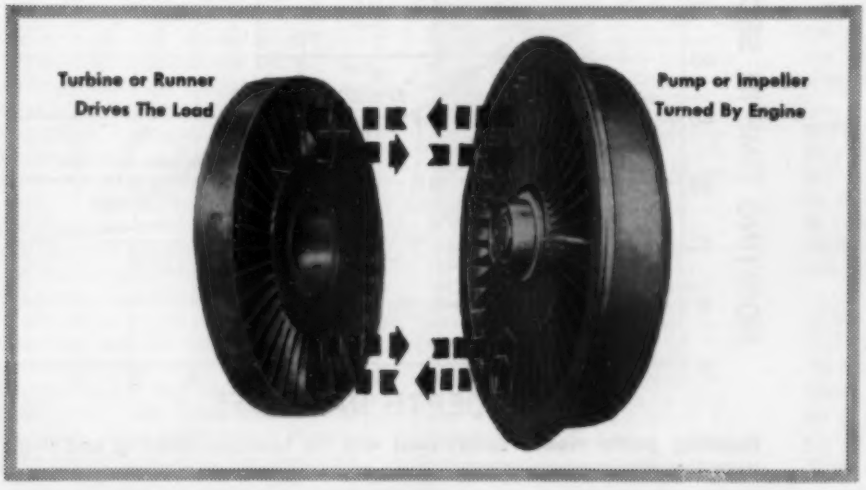
The oil moves around the power transmitting circuit at high speed. A complete trip takes about one-twentieth of a second.

Characteristics of Hydraulic Couplings

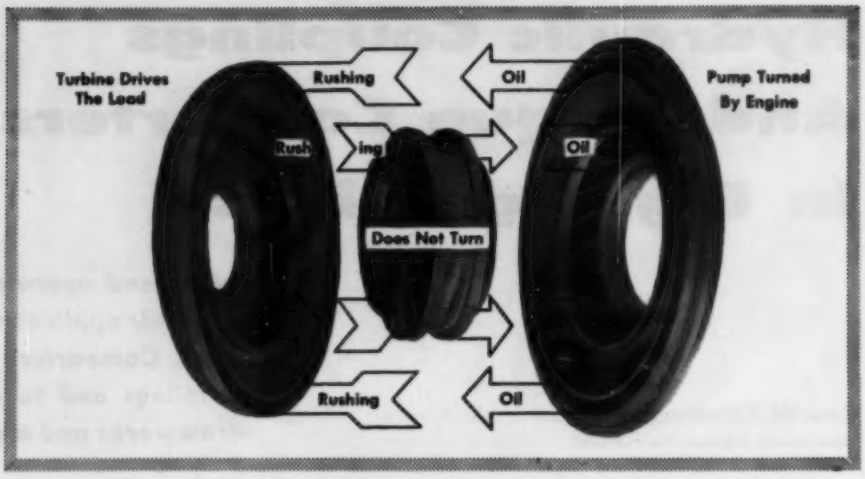
There is less shock transmitted by hydraulic couplings than by a mechanical drive. The oil in hydraulic couplings prevents the abrupt jar of a quick engaging clutch from being solidly transferred to the engines. Torsional vibrations from the engines are not transmitted to the compound and driven machinery at full strength. Shock loads traveling in either direction are cushioned when passing through the oil.

Stalling of the engines is eliminated, when the governors are correctly adjusted. For a very smooth hoisting operation, the drawworks clutch can be engaged with the engines idling and the pipe started by opening the throttles.

Hydraulic couplings with additional features are also available. There are hydraulic couplings with dump valves or bleed-off ports around the outside of the power transmitting circuit. These make it possible to quickly empty the power circuit to unclutch the engine



Inside the hydraulic coupling, showing the flow of oil from impeller to turbine or runner.



Basic parts of the torque converter include the pump, stationary guide, and turbine. This is a single stage unit.

from the compound. Hydraulic couplings with this feature can be run full, to transmit power; or empty, to disconnect.

Hydraulic couplings with variable filling also are available. They can be run with the power circuit full of oil for normal power transmission; empty for disconnect; or at any level in between. Intermediate oil levels are used to get delicate speed control for coring, fishing, or seating a plug. They can also be used to get very low pump speeds to meet an emergency.

No separate engine clutches are needed on rigs using hydraulic couplings that can be emptied. The hydraulic couplings serve as engine clutches.

The output shaft of a full hydraulic coupling, transmitting rated power at rated speed, runs about 93 to 96 per cent as fast as the engine. The torque or twisting moment, in the output shaft is engine torque less that required to run the oil pump, water pump, and fan, if any.

Characteristics of Torque Converters

Torque converters, as well as hydraulic couplings, are softer than mechanical drive. They too eliminate engine stalls.

Torque converters deliver a large percentage of rated engine power over a wide range of output speeds. The amount of power delivered is not reduced as soon as the load starts to slow down. Torque converters multiply engine torque to keep the power output high.

The best use can be made of the installed engine power when torque converters are exactly matched to the engines. The torque converters should have a power rating quite close to the power rating of the engines. If the torque converters used are too small, they will transmit less power than the engines are capable of delivering. If the torque converters are too large, the engines will be overloaded.

There are two types of torque converters in use in the oil fields. These are single stage and three stage. Single stage torque converters have one turbine; three stage torque converters have three turbines.

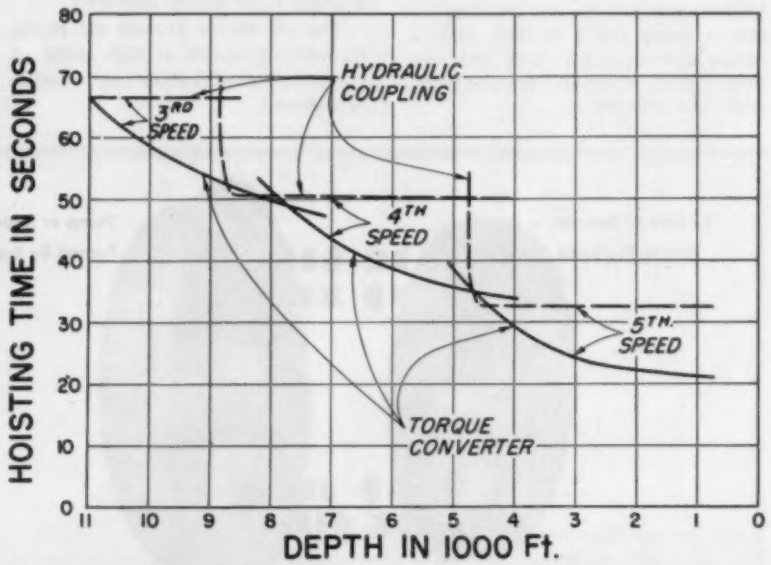
There is a difference readily noticeable to the driller, between a rig driven through single stage torque converters and rigs driven in other ways. When single stage torque converters are used, the engines run closer to their rated speed a large part of the time. There is practically no engine lugging. The popping sound of the exhaust, characteristic of engines running at full throttle and low speed, is gone.

Single stage torque converters protect the engines from overload better than other types of drives. There is no increase in the power demanded from the engines over a range of load speeds from the normal working range down to stall.

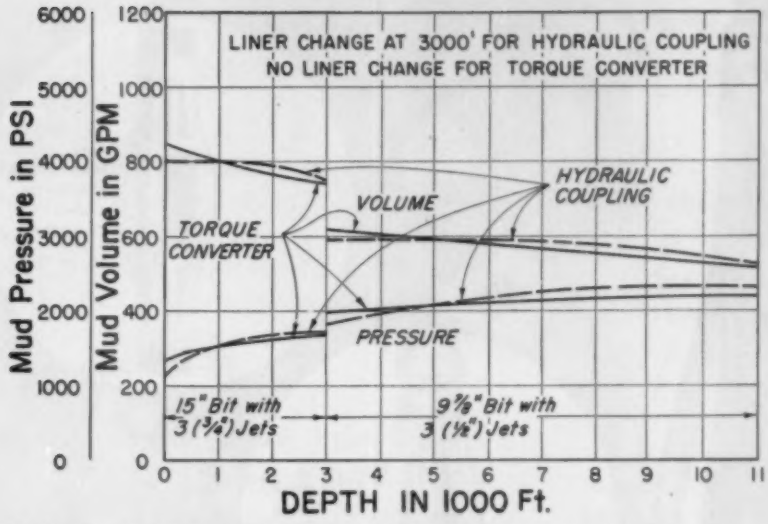
The efficiency of oilfield type single stage torque converters, with the pumps and fans required for cooling, varies from 80 to 90 per cent over the load range normally used.

Three stage torque converters give the highest stalled pull of any drive. This is useful on rigs with few transmission speeds. High stalled pull also can be used to make heavy lifts in high, such as coming off the slips when going into the hole at extreme depths.

The efficiency of three stage torque converters, with the cooling system, varies from 80 to 85 per cent over the normal working range.



Hoisting performance comparisons with the hydraulic coupling and single stage torque converter.


LINER CHANGE AT 3000' FOR HYDRAULIC COUPLING
NO LINER CHANGE FOR TORQUE CONVERTER
Mud Pressure in PSI
Mud Volume in GPM
HYDRAULIC COUPLING
VOLUME
TORQUE CONVERTER
PRESSURE
15" Bit with 3 (7/16") Jets
9 7/8" Bit with 3 (1/2") Jets
DEPTH IN 1000 Ft.

Mud pump performance with the hydraulic coupling and single stage torque converter drives.

Drawworks Drives

Hydraulic couplings in the drive to the drawworks are useful because they slip to soften a clutch engagement. The peak stresses in the chains and shafts are less than those on a mechanical drive. To a degree, the engines are also protected from the jar of a sudden clutch engagement.

Hydraulic couplings with variable filling are useful when doing delicate work. To get a very soft touch, the oil level in the power circuit is reduced until there is just enough pull to do the job. If something catches or sticks, everything stalls except the engines. If desired, the pull can then be increased by speeding up the engines or raising the oil level in the hydraulic couplings. An air actuated oil level control is usually provided at the driller's position. During normal trips in and out of the hole, the hydraulic couplings are left full.

Torque converters in the drive to the drawworks also soften the shocks on the engines and driven machinery. Variable fill arrangements are not usually provided on torque converters. Control, adequately soft for delicate operations, is obtained by reducing the engine throttle or unclutching one or more engines on a multiple engine rig.

Fig. 3 is a hoisting speed chart. It compares the hoisting performance of two rigs that are identical except that one has hydraulic couplings and one has single stage torque converters.

The curves for the rig with hydraulic couplings look like steps. The vertical portion of each curve represents the heaviest stands that can be lifted in each speed. The horizontal portion represents those stands where the engines run at rated speed for almost all of the hoist. As a trip progresses, the only material improvement in hoisting time comes when the stands get light enough that the next higher drawworks speed can be used. Therefore, only a few of the stands hoisted in each transmission speed use full engine power, the rest are too light to use full power in one transmission speed and too heavy to be hoisted in the next higher speed.

The curves for the rig with the single stage torque converters show progressively better hoisting time for each stand. This occurs because the engines run very close to full speed and full power for each stand. The torque converters convert this power to increased speed as the stands get lighter.

The Author

Ross W. Colebrook has been closely associated with the design and application of hydraulic drives to drilling operations. For the past eight years, he has been a member of the General Engineering Department of the National Supply Company and is presently development engineer for this company at Houston, Texas. In this capacity, he has been engaged in the field application of power drives to the drilling industry. Also Colebrook has been active in AAODC committee work. He is a graduate of Purdue University and while with The National Supply Company has been engaged in graduate work at the Carnegie Institute of Technology.

Another factor that decreases the hoisting time for the rig with single stage torque converters is the short time required for acceleration. Torque converters have a high starting torque. In effect, they start each stand in low and automatically shift to higher speeds as the blocks accelerate.

Mud Pump Drives

Hydraulic couplings in the drive to the mud pumps soften shocks and add utility to the pumps. When variable fill hydraulic couplings are used, the pumps can be run at very slow speeds without danger of stalling the engines. By manipulating the filling, the pump speed can be adjusted from stall up to a speed corresponding to the pressure that full engine torque can produce.

Torque converters in the drive to the mud pumps also reduce shock loads on the engines, drive, and pumps. In addition, torque converters make a two speed pump drive unnecessary. High mud pressure at low pump speed is obtained when the throttles are open and there is sufficient resistance to pump against. Lower mud pressures are obtained by reducing the throttle setting.

At the top of the hole where mud pressures are low, a mud pump driven through torque converters can be run faster than its rating. Torque converters deliver the engines' power as extra speed when the load is light. The highest pump speed that suction conditions will allow can usually be obtained by manipulating the throttles.

Liner changes are needed less often when the mud pump is driven through torque converters. Liners need be changed only when the pump has slowed down to the point where the torque converters are no longer operating efficiently, or the pump is loaded beyond an economic point. The engines stay near rated speed. It is not necessary to change the liners to bring the engines back up to speed.

Fig. 4 is a comparison of the performance of a mud pump driven through hydraulic couplings and a mud pump driven through single stage torque converters. One liner change was made in the pump driven through hydraulic couplings. There was no liner change made in the pump driven through single stage torque converters. The average performance of these two pumps is almost the same. The ability of the torque converters to maintain nearly full engine power over a wide range of pump speeds eliminated the need for a liner change. It was necessary to change liners in the pump driven through hydraulic couplings to keep the engines near full speed and rated power. ★ ★ ★

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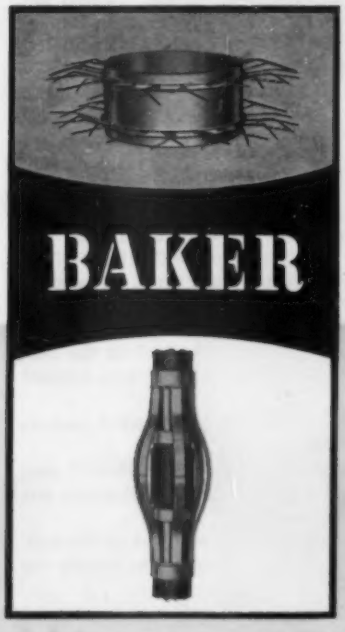

Baker Wall Scratchers also meet your specific needs because they are available with either 4½-inch long scratcher wires, or with 2½-inch long wires. You can also select either the HINGE-LOK Type which is hinged for easy mounting, or the SOLID RING Type which is *slipped over the casing.*

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Enough water to cover a football field 10 inches deep was pumped into the Sprayberry formation in 96 minutes along with 200,000 pounds of sand. The total horsepower of the trucks was about 7000. Hydraulic horsepower was rated at 4500.

200,000 Pounds of Sand and . . .

250,000 GALLONS OF WATER USED IN BIGGEST FRACTURE JOB

Eight pumping units and two mixing trucks and eight sand trucks manned by some 35 men did this unique job.

Remote control panels for operating the big pumps.

THE biggest fracture type job in the history of the oil industry was accomplished Tuesday, July 24, by Dowell Incorporated when 250,000 gal of water and 200,000 lb of sand were pumped in 96 minutes under high pressure, into an oil well in the Spraberry area, 25 miles southeast of Midland.

The system used is known as "Riverfrac." Fresh water, containing special de-mulsifying substances, was used in conjunction with carefully graded sand. It was pumped into the formation at high speed by 18 mobile units of various descriptions. Pumping trucks alone generated total engine horsepower of more than 7000 hp. Hydraulic horsepower totaled 4500.

The blended water and sand was pumped into the well at an average injection rate of 2184 gal or 52 bbl a minute under a surface working pressure of 3400 psi.

The well which received the unique treatment is the Hanley Company Driver No. A-2. Completed at 7767 ft for a good flow of oil in 1953, the well declined in production. In 1955 30,000 gal of refined oil containing 60,000 lb of sand was injected into the well which stimulated production to 134 BOPD. It was pumping 27 bbl a day when taken off production for the Riverfrac treatment.

The previous record in an oil well insofar as water volume is concerned was established in a fracturing job in the McCamey Pool when close to 100,000 gal of water were injected into a well.

The water was transported to the well site by truck tankers and stored in twelve 500-bbl tanks.

Besides several pieces of auxiliary equipment, Dowell used two blenders to mix the sand and water, eight sand trucks and eight truck mounted pumping units.

There were 10 lines running from the pumpers to the wellhead which was fitted with a special "header" to receive the lines.

If the huge job gains its objective, it well may be that the Spraberry will be entering a new era. ★ ★ ★

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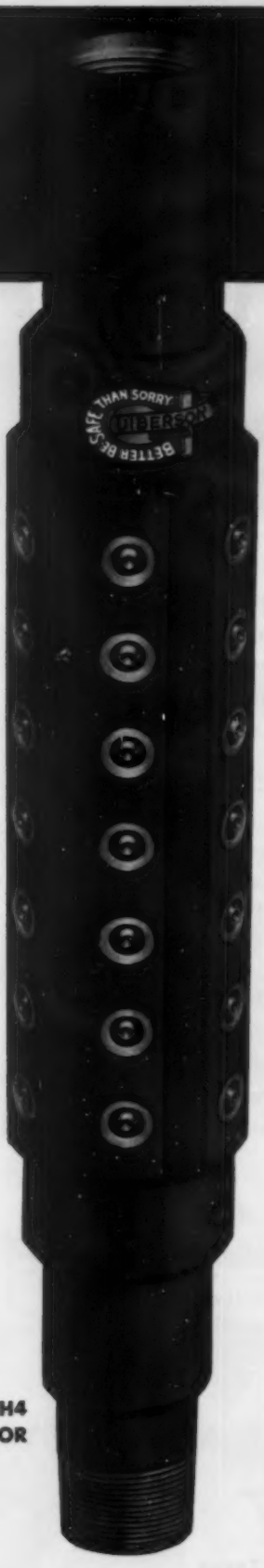

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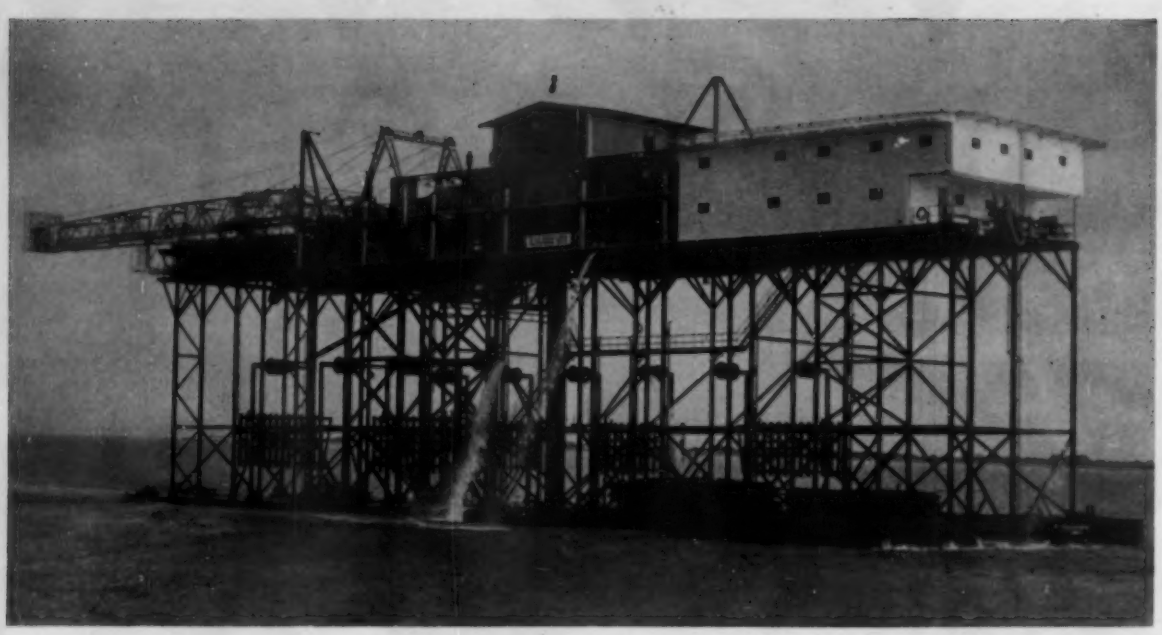

"M & H Drilling Platform No. 12" is on its way to its first location off the coast of Louisiana for The Texas Company following submersion tests at Galveston.

Operation "Bootstraps" . . .

P 422.912.5

NEW IDEA in Drilling Barge Assembly

Robert C. Alexander, Jr.
Christenson & Graham, Inc., Pasadena, Texas

Hydraulic jacks supported by fixed platform legs raise decks from ground level to elevated position in record time to lower construction costs and reduce hazards

EXCLUSIVE

QUICK completion of the "M and H Platform Barge No. 12" marks another milestone in the mushrooming offshore drilling industry. Office-building construction techniques used to assemble the latest barge for Morris & Hamilton, Inc., drilling contractors, Houston, Texas, have cut costs, construction time, and offered a new degree of personnel safety.

Key to the success of the project lay in on-the-ground construction of barge decks, raised to elevated levels by hydraulic jacks mounted on the support columns.

A second unique feature in the construction of Barge 12 was the assembling of the crew quarters, on the ground and away from the immediate platform site. The completed 75-ton unit was set atop the barge, a new advancement in the sub-assembly method of construction.

Rig Specifications

The platform was designed by Christenson & Graham, Inc., consulting engineers and naval architects of Pasadena, Texas, and was constructed by Sprague Welding & Machine Works at its Greens Bayou yard near Houston.

The unit is designed to drill in 30 ft of water and supports one of the largest drilling rigs yet assembled, including the largest drawworks ever built driven by 2400 available diesel horsepower supplied to the drawworks and pumps. Rotary and mud mixing pumps are independently driven, making a total of more than 3600 available diesel horsepower for the entire rig. The cantilever type mast, traveling block, swivel and hook have a 500-ton capacity rigged with 1⅜-in. line. The rig has been put in the 20,000 to 25,000-ft drilling class.

Basic hull of the vessel is 230 ft long, 99 ft wide at one end, 75 ft wide at the slot end, and 11 ft deep with a 22 by 70 ft drilling slot. Centrally located in the hull is a pump room, accessible from the upper structure through a 4-ft diameter, water-tight, access tube. This pump room contains the two 1500 gpm ballast pumps, fresh water transfer pump, stand-by cooling water and fire pump, and one sump pump.

fractures zones that can't be isolated

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Many a well that shows promise... but fails to keep it... may be multiple-fractured the Halliburton way to increase production profitably. Well conditions may be such that packers cannot be used to isolate individual zones. Continued injection may simply extend existing fractures, making additional fracturing economically questionable. However, if these fractures are temporarily plugged, pressure build-up acts to establish a new fracture at a different elevation. Alternating this procedure with conventional fracturing methods using Halliburton's continuous Multifrac process, obtains and extends additional fractures at different levels.

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MULTIFRAC does not require segregation of individual sections. Production has been greatly increased by using MULTIFRAC applications where portions of open hole are too large or otherwise unsuitable for packers... where oil bearing sections have great thickness... where series of perforations in casing are closely spaced.

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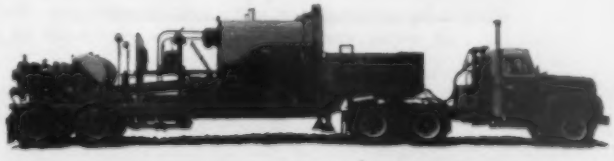

HALLIBURTON FRACTURING SERVICES

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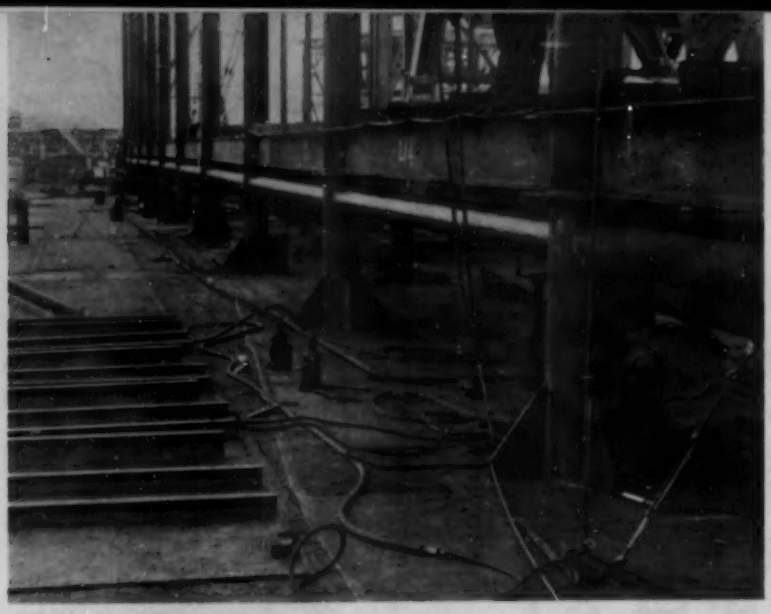
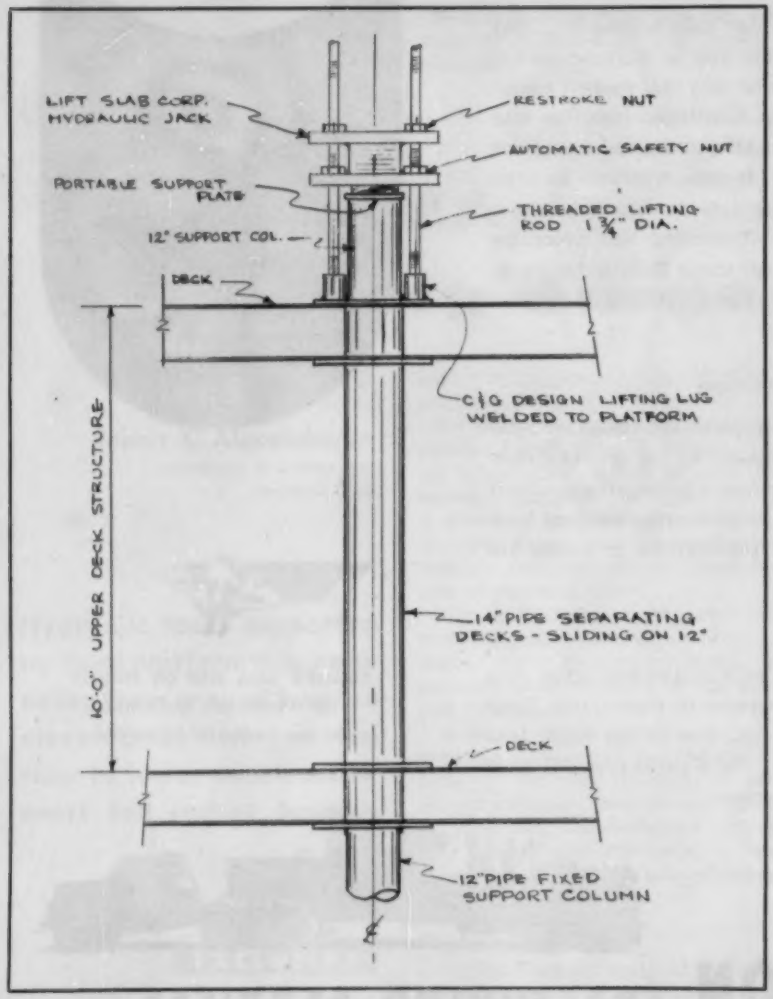


Texas deck, or upper structure deck, rests on the deck of lower hull. Note the slipping joints on 12-in. pipe columns and column attachment through hull deck.



Hydraulic jack raised the upper decks from the hull deck by sliding the 14-in. pipe up the 12-in. pipe fixed support columns.

The Texas deck consists of two levels, the lower of which is 65 ft above the bottom of the basic hull with 10 ft between the two levels, making a total height of 75 ft. The Texas deck is supported by fixed columns suitably braced to withstand the forces of wind and wave. The compliment of machinery installed on the Texas deck has been carefully planned to carry on the operation of drilling in the most economical manner. Careful consideration has been given to accessability of all components of machinery for maintenance as well as for the drilling operation itself.

Crew quarter accommodations are provided on the Texas deck for 56 men. These quarters are completely air conditioned with adequate sleeping quarters, showers and toilet rooms, scullery, galley, mess hall, lounge and a game room. A helicopter deck is provided on the roof of the quarters.

Electric power is furnished by two 175 kw, 440 a-c generators driven by twin diesel engines.

Conventional Platform Construction

In the preliminary cost analysis of any large construction project such as this platform it is immediately apparent that the actual cost, relative to the height of the structure, can easily double itself if not carefully controlled. Another basic aspect of the project, relative to height, is personnel safety.

In the past, various methods of construction of the high fixed leg type of platform have been utilized to try to minimize cost, cut time, which is always closely tied to cost, and make working conditions as safe as possible for the men on the job.

One of these methods of construction and erection which has been used the most often and with the greatest success is the sub-assembly method. With this method, large sections, assemblies or units are fabricated on the ground in the conventional manner then lifted with large cranes to their respective positions high on the structure and welded off. Outfitting, such as piping, electrical, etc., is then performed.

It can readily be seen that this method is by far better than lifting each small piece of I-beam, angle, plate, bolts, plate, pipe, etc., into place high in the air. But even with the sub-assembly method there are numerous disadvantages and costs are still high. Three of the most prevalent disadvantages are the high cost and time lost waiting for big lifts, sub-assembled structures must have added design and engineering work performed for their proper application, and the attachment

For The Disposal Of Salt Water . . .

This BS&B AQUA-KLEENER System was recently installed for salt water disposal service on a lease south of Oklahoma City by Cities Service Oil Company. Consisting of one 10′ x 3½′ permeable plate filter and one 10′ x 15′ backwash tank, it is currently handling 5,000 bbls./day although it has a rated volume of 8,000 bbls./day.

Cities Service Chose BS&B AQUA-Kleener*!

Like Cities Service Oil Company, more and more lease operators with salt water disposal problems involving sub-surface injection, surface disposal or offshore disposal are installing today's *outstanding* water conditioning and filtering system—BS&B AQUA-KLEENER!

AQUA-KLEENER is a closed type system which prevents air from contacting the water—thereby minimizing corrosion, excluding air-borne bacteria and preventing the oxidation of such substances as soluble iron. When the improved filtering equipment shown here is used in conjunction with the BS&B AQUA-KLEENER oil skimmer it removes oil traces and solid particles from lease-produced water, well water or surface waters and greatly extends the service life of water injection wells.

The use of permeable underdrain plates and Anthrafilt No. 1 as the filtering medium in the AQUA-KLEENER Filter gives longer filter runs, superior operating results and reduced maintenance cost because of more thorough cleaning during backwash, and the elimination of filter bed disruption.

*AQUA-KLEENER is a trade name of Black, Sivalls & Bryson, Inc.

If you have a water disposal problem, why not talk it over with your BS&B Man? He'll gladly recommend the right combination of AQUA-KLEENER equipment to take care of it. Or, you may write to . . .

EFFICIENCY OVER 60 YEARS BS&B RELIABILITY ANOTHER EXAMPLE OF PRODUCT LEADERSHIP

BLACK, SIVALLS & BRYSON, INC.

Oil & Gas Equipment Div., Dept. 1-C10

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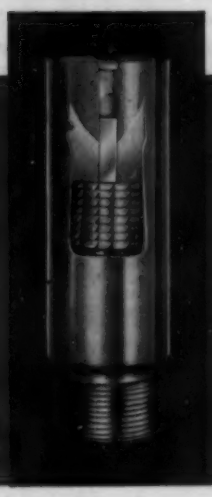
BURNS { family of tools }

Save That Hard To Get Casing!

The Burns lead seal pack-off type casing hanger is the only hanger manufactured with the sealing element located below the slips. When retrieving the oil string there is no danger of broken lead jamming the slips. Slips will not set or hang up going into the hole — will not bulldog on retrieving.

Burns double slip hanger for heavier, longer oil strings, designed with the lower set of slips offset, forming two circles of slip contact.



The Burns plain type casing hanger embodies all the advanced features of the Burns line — one-piece streamlined body with the slips contained in separately machined recesses in the body. The entire area of each slip is completely supported throughout the full length of the slip travel.

LOOK BEHIND THE SLIPS

Burns hanger with hold-down slips which set automatically after casing is suspended.

Circulating type hanger with lead seal pack-off. On cementing jobs this hanger assures easier circulation around the hanger and a positive seal after cementing.

Delayed action lead seal hanger. Same features as the circulating type except the by-pass ports are eliminated. Hang your oil string, circulate and cement before closing the lead seal packing element.

Burns setting tool. Note the absence of drag springs, slips, etc. on the outside of the body. This setting tool does not depend on friction springs to set the hanger. All hangers are set solely by the rotation of the setting tool.

BURNS CASING HANGERS
YOUR BEST ANSWER TO TODAY'S PIPE AND CASING SHORTAGE

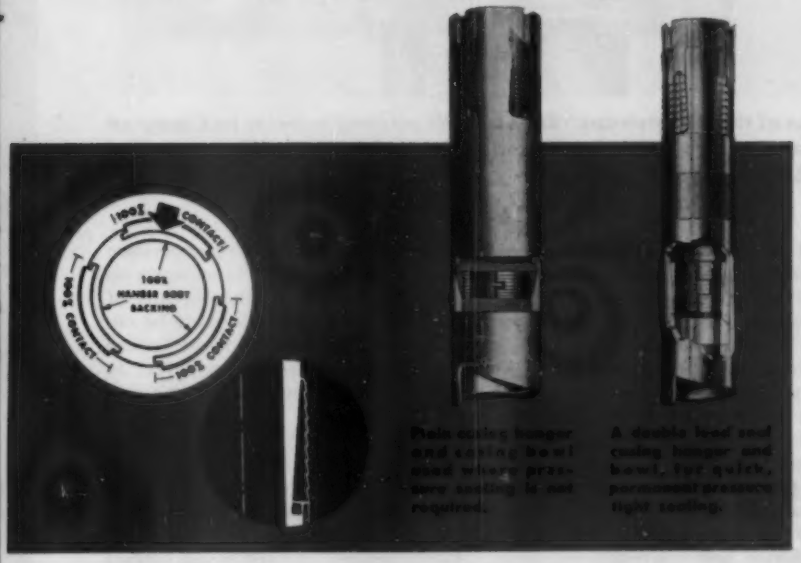
Reclaim Casing in Old Wells

ECONOMY

Splice your oil string with this tool and recover the extra casing, simply and safely. This tool is used extensively to recover extra casing strings in old oil wells. It is the only casing hanger and combination casing bowl that will suspend the oil string into its original tension without running a full string of casing to the surface for suspension. Thousands of feet of casing have been salvaged with this tool and the well placed on production as before the recovery of the extra casing took place.

SLIP DESIGN

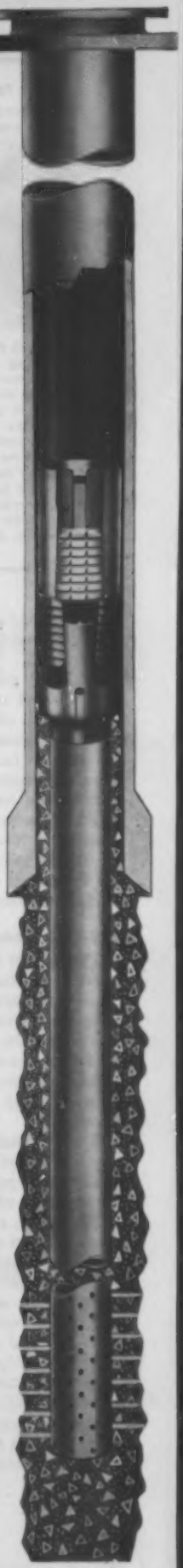
Secret of Burns casing hangers rests on the slips. Instead of the conventional tapered cone to force slips outward, the Burns patented construction provides specially breached single plane runners on which slips travel with a full 100% backup contact at all positions. No "two point" slip support and no cracked slips. Instead, a true 100% wedge — the Burns patent.



Plain casing hanger and casing bowl where pressure sealing is not required.

A double lead seal casing hanger and bowl, for quick, permanent pressure tight sealing.

This combination used for repairing and patching casing. Delayed action lead seal hanger in combination with lead seal casing bowl saves overlap to the surface.



KEEP UP YOUR PRESENT DRILLING COMMITMENTS WITH LESS INVESTMENT PER WELL. USE A CASING HANGER.

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ALSO SOLD THROUGH SUPPLY STORES

The Author

R. C. Alexander Jr. was the chief designer and project engineer for Christenson & Graham, Inc., of Pasadena, Texas, throughout the design and construction of the Morris & Hamilton mobile platform.

Before joining Christenson & Graham, Inc., he was a project engineer with Port Houston Iron Works, Inc., handling design and construction of ship conversions, U. S. Navy projects, and offshore drilling equipment. Prior to this he was in charge of the mechanical section of the engineering department of Todd Shipyards, Houston, after graduating from the University of Houston.

Alexander began his marine experience on the East Coast during World War II, then moving from Washington, D. C., to Texas after serving in Europe with the U. S. Army Air Force.

of larger lifted sections at elevated condition is always dangerous and difficult to perform.

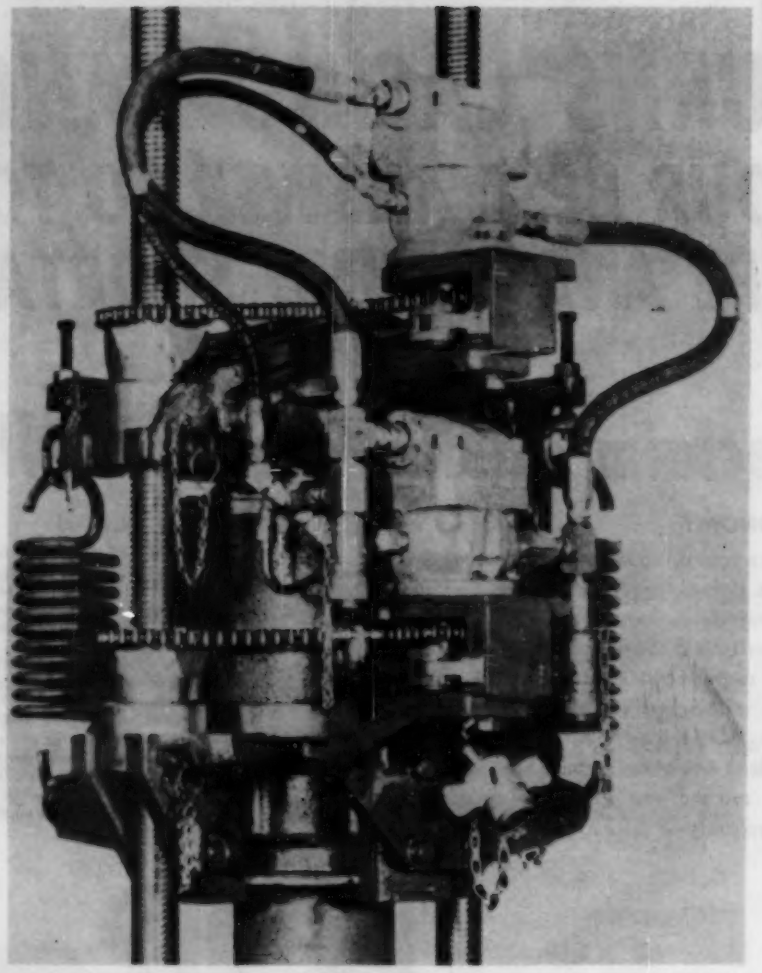
With the preliminary platform design in mind and considering the various aspects of these present methods of construction, the designers looked for ideas to facilitate the reduction of the fore mentioned problems and yet not become too involved or complicated. The basic conclusion was reached in that the upper structure should be built down on the deck of the lower hull and raised as a unit to its final position and welded off.

Lift-Slab Construction

The answer to the simplified lifting operation came from the firm's land-based construction experience, in utilizing the patented hydraulic jacks and services of the Lift Slab Corporation of San Antonio, Texas. The lift slab jacks and lifting rods give the appearance of lifting a structure by its own bootstraps.

The lift slab jacking operation is familiar to civil engineering due to its wide use in past several years in the construction of school buildings, hospitals, offices, etc. The hydraulic jacks were designed and are principally used to lift the concrete slabs for successive floors or roofs. The basic idea is the same as that sought for the platform, that is, to build on the ground and jack into final position.

In a building, the ground floor concrete slab or foundation is poured with the supporting pillars, steel pipe, beams or concrete columns, standing up from it the desired height of the structure, then the successive floor slabs are poured on top of one another with an anti-bonding agent between the slabs. A steel lifting lug is cast in the concrete around the columns in each slab, a lift slab jack placed on top of the column with lifting rods connecting to the lifting lugs. The pile of successive floors are lifted with a stop at each floor to weld or secure each at its finished elevation.

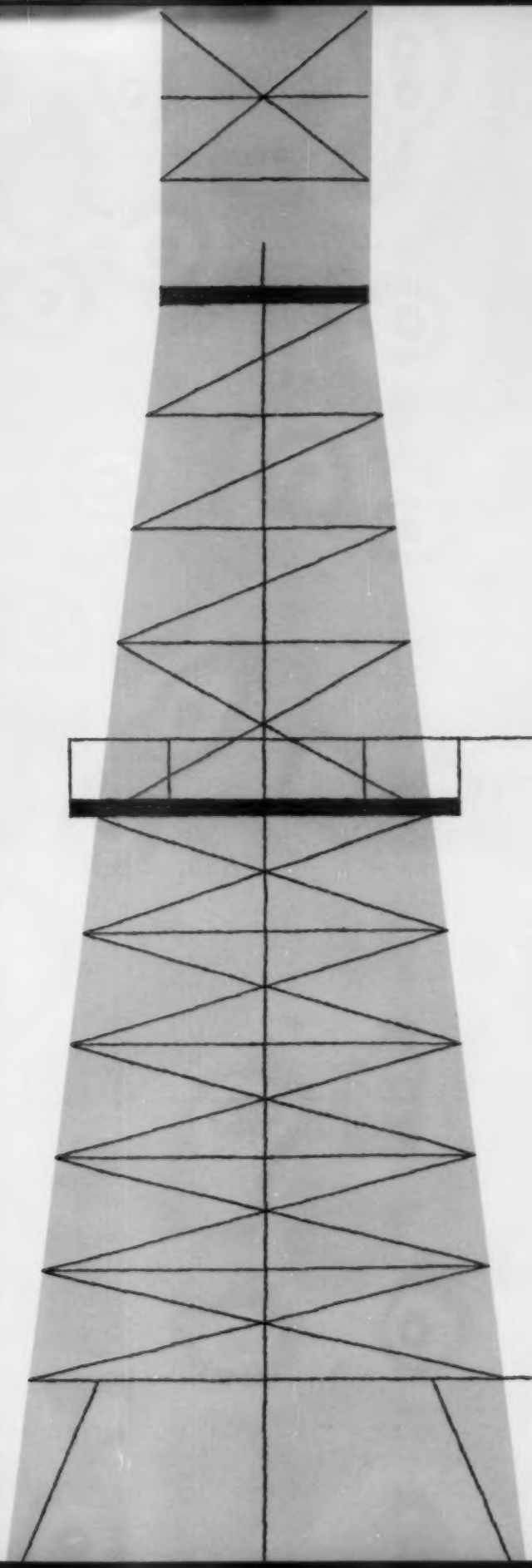


Success of the "Bootstraps" lift was in this patented hydraulic jack designed and leased by the Lift Slab Corporation. Jack was attached to lifting lugs welded to deck platform.

The plan of construction of the platform as a whole called for the utilization of an existing lower hull to be strengthened and converted for submersion while afloat, then columns erected and the upper structure fabricated on deck of the hull. This meant the jacking operation would be performed while afloat and seemed to be the only point of hesitancy on the part of the Lift Slab engineers. After the complete stability of the operation was proved, their enthusiastic cooperation was added to the operation.

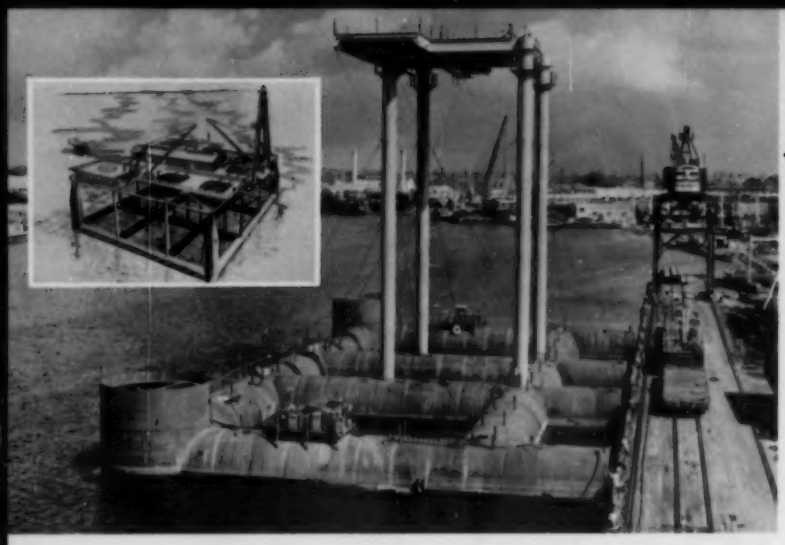
Steps in lifting. The lifting operation was resolved into a lifting sequence on a design drawing so that lengths of columns and lifting rods could be coordinated. The lift was to be broken into "first lift" and "second lift" to suit the slenderness ratio of the free standing columns.

Design of the platform structure, columns, and bracing proceeded, with calculations based on the usual criteria for offshore structures but also including checks into any added requirements possibly imposed by the jacking loads on the columns and moments in the structure. By adhering to a certain jacking sequence and placement of jacks, no additional factors need be added in the calculations for jacking as the loads imposed were small in comparison to the high loading imposed by the elements. Under actual lifting conditions double level portion of the deck structure was actually too stiff or rigid



Everything in sight is DIESEL-ELECTRIC

A report on rig construction at Orange, Texas



1

Shown here is Kerr-McGee's Rig No. 47, a mobile type of drilling device under construction by American Bridge Division of U. S. Steel. Three Electro-Motive Power units will be located on the rig, supplying power for mud pumps, drawworks and rotary table. Due for completion late this year, the drilling device brings to three the number of Electro-Motive Powered rigs for Kerr-McGee.

2

Rigs No. 54 and 55 for Offshore Company are shown here nearing completion in the American Bridge yards of U. S. Steel Corp. These mobile drilling barges, each powered by three 875 hp. Electro-Motive Power units, are capable of operating in waters up to 100 feet in depth. Each barge measures 200 feet long and 104 feet wide and contains eight hydraulically operated, 225-foot supporting legs.

3

This tender, one of four being converted for a major oil company, is shown at the Levingston yards at Orange. A former LST, the tender features a heliport and is completely outfitted with modern eating, sleeping and recreation facilities for the crew. Two 12-cylinder Electro-Motive Power units rated at 1200 hp. each will be located in the tenders to power large mud pumps.

4

The Penrod Drilling Company's W. H. (Bill) Dordan, a submersible island drilling barge, powered by 3 Electro-Motive units, is one of two recently christened. Built by the Levingston Shipbuilding yards, the Dordan is now drilling for Placid Oil Company near Houma, Louisiana. The second Electro-Motive powered barge, the Tom Sorrell, is also completed and drilling for Placid Oil Company in Lake Washington, La. Both of these barges are capable of drilling 18,000 feet in 19 feet of water.

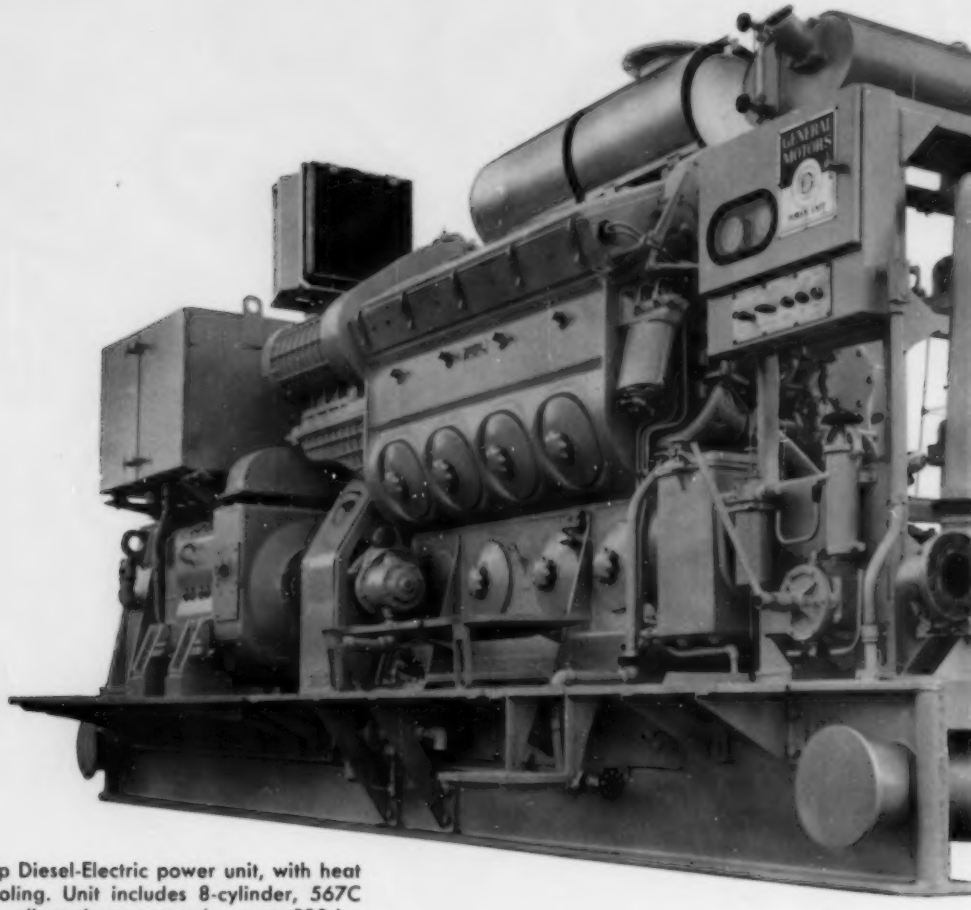
Six Rigs – Four Companies – All Diesel-Electric ... and ALL ELECTRO-MOTIVE POWERED

We had this aerial view of the yards at Orange, Texas, taken for just one reason. It tells more literally than words how Electro-Motive Power is being accepted in the drilling industry everywhere. In this one photograph, there are six offshore drilling platforms or tenders in various stages of construction for four different concerns. All have one major thing in common: *each is equipped with Electro-Motive Diesel-Electric Power.*

If your interests lie with deep-well drilling on land, or with offshore drilling, the next few pages will tell you why Electro-Motive Power is rapidily assuming the position of dominant leadership in such applications.

ELECTRO-MOTIVE

offers new standards of flexibi



SR8-W 900 hp Diesel-Electric power unit, with heat exchanger cooling. Unit includes 8-cylinder, 567C Diesel engine, all engine accessories, two 500-kw direct current generators, and generator control cabinet. All mounted on a steel sub-base, 21-feet long, 6-feet wide and 9-feet 7-inches high.

Completely Integrated Design

Each of the major components designed and built to work together—one manufacturer—one source of responsibility.

Maximum Portability

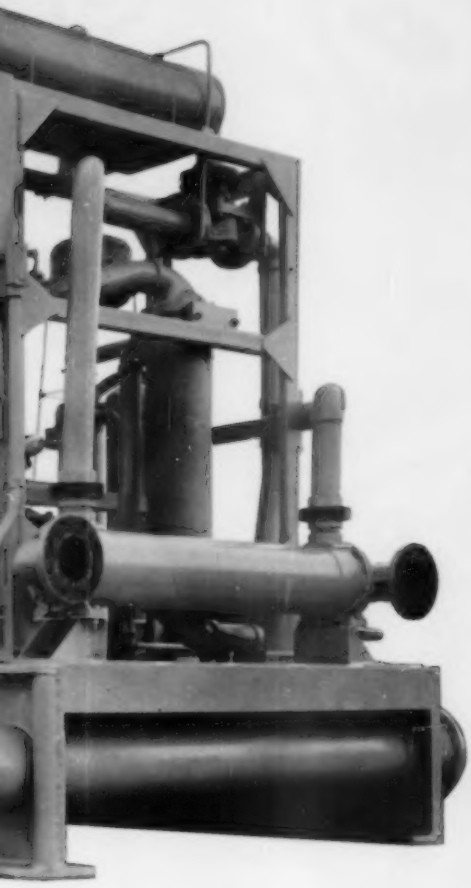
All components on skids with weight reduced to a minimum. Units are ruggedly built to withstand handling. No position problem—slashes setup and moving time on land rigs.

Unmatched Flexibility

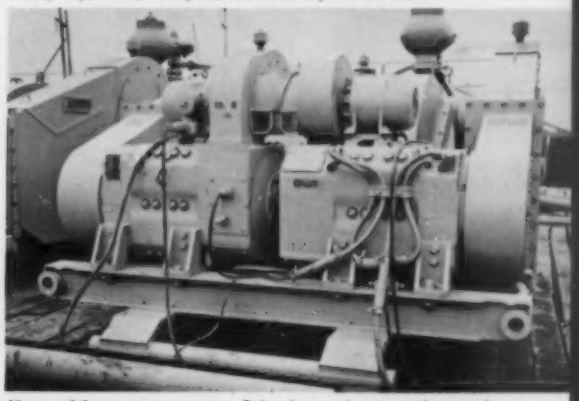
At a flick of the selector switch on the driller's control panel, power can be selected from one or more generators to meet any power requirement.

VE POWER

ibility, efficiency and economy



Driller's control stand is located most convenient to total operation. From a central position, the driller has complete control of all Diesel-electric equipment, including engine speed, mud pump, hoist, rotary table and safety shutdown.



Motor-driven components. Drive for mud pumps, drawworks is supplied by 625 hp. direct current electric motors. These motors provide smooth and rapid acceleration of loads with positive control of speed and torque. They also permit fast setup because each is connected to the main generator through simple, flexible power cables.

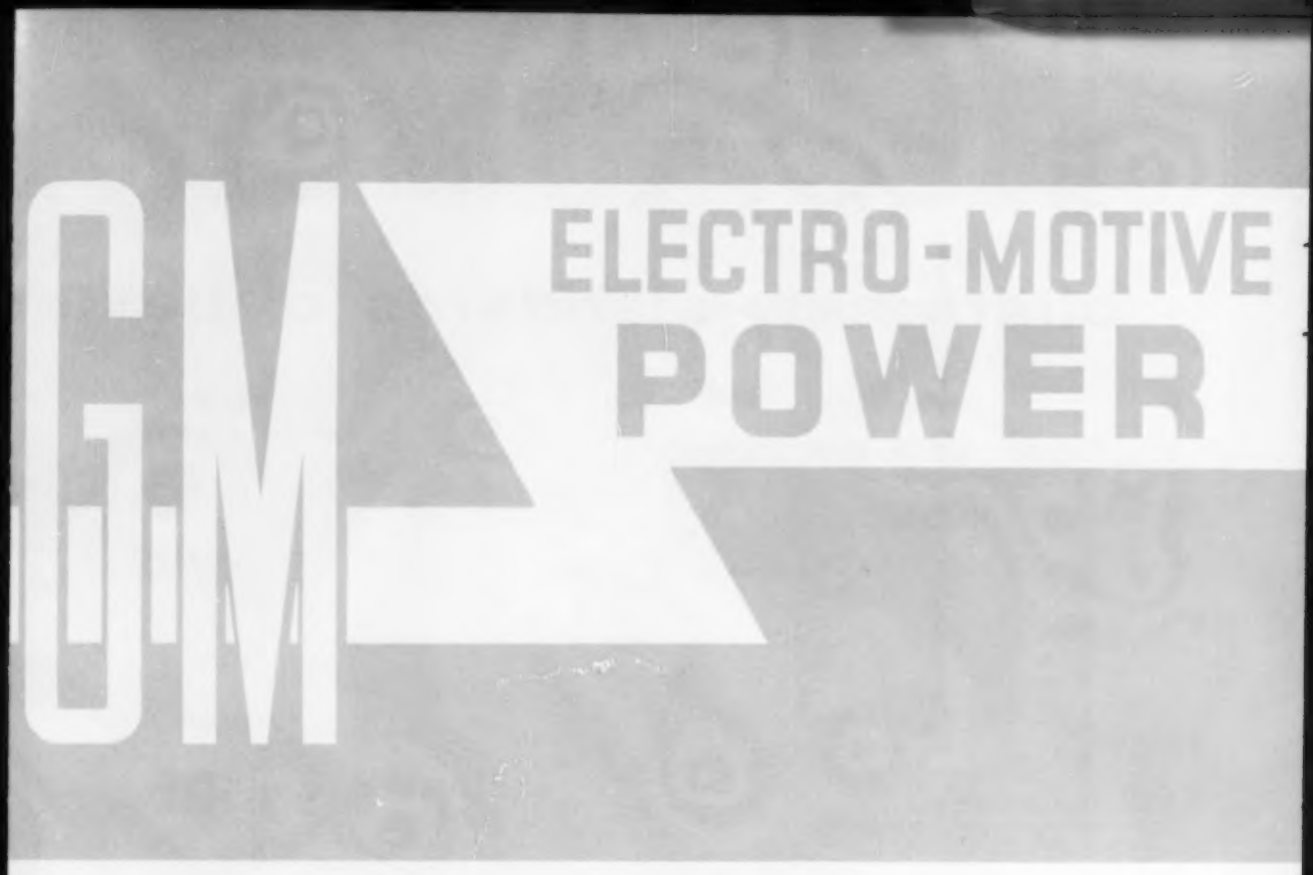
Proven components. This compact electrical control cabinet utilizes components that have proven themselves in thousands of General Motors Diesel-Electric locomotives. The tested dependability of this equipment is your assurance of lower cost per foot of hole drilled, and longer, trouble-free operation.

Simplified Control

Centralized position of all controls for driller's convenience—continuously variable drawworks speed control and complete rotary table torque control at the driller's finger tips.

Low Drilling Costs

Lower first cost and lower cost per well drilled. Smooth electric power—flexible control —means less down time, faster drilling.



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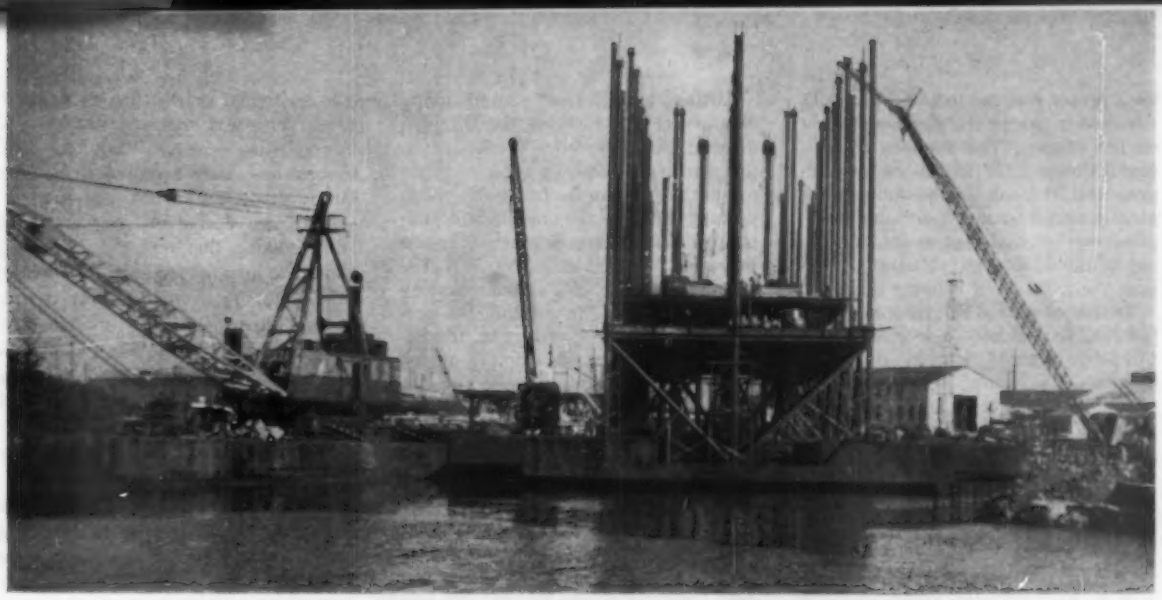


Jacks are in position atop the support columns after the "first lift" stage, with columns set for "second lift." Lower bracing is in place.

to lift ideally. Whereas a concrete slab or single level deck will flex to suit the jacks, this structure would allow one jack to overload, cantilevering too much of the structure. This condition called for close observation of the jacks. Of course, the operation would have been much more complex if cantilevered sections could not have been utilized, since there were 50 columns in the entire structure and only 26 were used for jacking, leaving many large open span areas and cantilever sections.

Structure loading. As the design advanced, structure weights and machinery locations and weights became firmly established instead of estimated, and structure loading diagrams were prepared to strategically locate the jacks to be as evenly loaded as possible. Criteria for the number of jacks to be used had to be based on the large area in which they were to be spread to distribute the loading rather than jack lifting capacity. Using the 28 jacks, maximum loading was calculated to be 25 ton and ranged down to a minimum of 12 tons. The platform constructed to this point and carrying various pieces of machinery and equipment weighed 350 tons and was roughly 45 ft wide and 230 ft long. The lower level 8-in. pipe horizontal bracing also was fabricated on the hull deck, on slipping collars around the 12-in. columns, attached temporarily to the under side of the upper structure, and carried up with the jacking. This horizontal bracing level, 17 ft above the hull deck determined the end of the first lift. When the bracing was carried up to this level, it was welded to the 12-in. columns. The lower diagonal bracing, which had

Prefabricated crew quarters were lifted into place as a unit on the raised platform.

been precut was erected, and the jacks removed to permit the platform to rest on the bracing. The columns for this first lift were 30 ft tall for the low sections and 40 ft tall for the double deck area. A simple, grooved, portable ¾-in. plate was all that was needed on the top of the 12-in. pipe columns to prevent the jacks from slipping off.

Details of second lift. In preparation for the "second lift," a second section of predetermined lengths of 12-in. columns, averaging 30 ft in length, was set in place. The jacks then were added to the top of these and the "second lift" of 39 ft was made and the platform welded into place. During the lift, the longest columns were used, some being 63 ft free standing. Ehler's formula is used to determine the safety factors involved.

It is noted that the 12-in. pipe column is the largest diameter that can be used with this jack as it was used. As mentioned earlier, 28 jacks were used on 26 columns which was the result of using two jacks each on two 16-in. columns. The two 16-in. columns were utilized in the very heavily loaded mud pumps and mud pit area. The spread on the lifting rods being only 15 in. necessitated building a simple saddle on the top of the 16-in. column and using a jack on each side of the column.

It is also noted that the Lift Slab Corporation is planning jacks that will spread out to 25 in. center-to-center on the lifting rods.

Lifting jacks. The accompanying diagram (Fig. 3) shows the arrangement of the jacks as they were used on the platform. These sit on a plate on top of the column, the hydraulic piston pushing down on the column and pulling up on the 1¾-in. diameter threaded lifting rod, welded lifting lug and platform. The entire jack is motivated by hydraulic power. In addition to performing the jacking operation, the hydraulic fluid actuates motors which turn down the safety nuts on the lifting rods to prevent any possible lowering in case of a failure of jack or hydraulic line. The motors also turn the restroking nuts for pulling the jack back into position for another lift after about a 3-in. power stroke.

Cutting erection time. The entire jacking operation of this platform took about two weeks, this includes the time necessary to erect the permanent cross bracing as the lift progressed. It is the opinion of the writer that this time could be cut in half with closer work scheduling, utilizing the experience gained with this lift.

Crew quarters. Second deviation from accepted platform construction methods was in the erection of the crew quarters. The same basic criterion for construction was required for the quarters as for the platform structure; it had to be built at ground level and lifted into place.

In this case, the lifting was to be done by Brown & Root's marine 250-ton revolving crane, the "Lindsey." This crane was required not for its weight-lifting capacity but for the tremendous reach required to set the quarters structure on the platform.

With this design criterion in mind and knowing that any weight saving would be advantageous to this lift, as well as to the overall stability of the vessel and original cost, another first was incorporated. The all-welded steel house structure was designed around a theory of "Stran-Steel" structurals and stressed skin 10-gage plate. This design of structure lends itself well for this type of application.

Lifting lugs were fabricated in the helicopter deck and after the building was fabricated, two spreader bars were used, and all 75 tons of quarters were set on the upper platform without a buckled plate.

Time, cost and possibly a high accident rate were saved by building on the ground, as this crew quarters was built about one-half mile from the platform job site.

Operation "Bootstraps" was a success, cutting erection expense, saving time, and above all lessening that obvious danger of massed manpower working at elevated positions. This entire project was ordered, designed, constructed, and moved to a location in the Gulf of Mexico in only six months. ★ ★ ★

New Twist in Fracturing . . . With Small Rubber Balls

SMALL rubber balls, only ⅞-in. in diameter, are being introduced to the oil industry in the well fracturing and acidizing. They are a part of a new type of well treatment control developed and tested by the research and operation division and the pumping service engineering department of The Western Company, Midland, Texas.

Using this new method to control fracturing and acidizing, the operator can complete jobs previously listed as multifracture operations in only one stage, no matter how many zones are to be treated, length of a single zone, or how many feet separate the perforated intervals. The new method also can be utilized in dual pay treatments.

The small spheres in reality are free floating valves used during fracturing and acidizing treatments in both new and old producers.

Western's trade name for the new method is Perforation Ball Sealers.

The principle involved is very simple. Rubber balls, designed to rigid specifications, are injected into the treating fluid, flow down the casing in the fluid stream and seat over those perforations taking fluid at the lowest pressures.

The ball valves can be used at a minimum injection rate of seven barrels per minute. As the perforations are sealed off temporarily by the balls, the treating fluid is diverted into tighter sections for a complete treatment of the entire pay section.

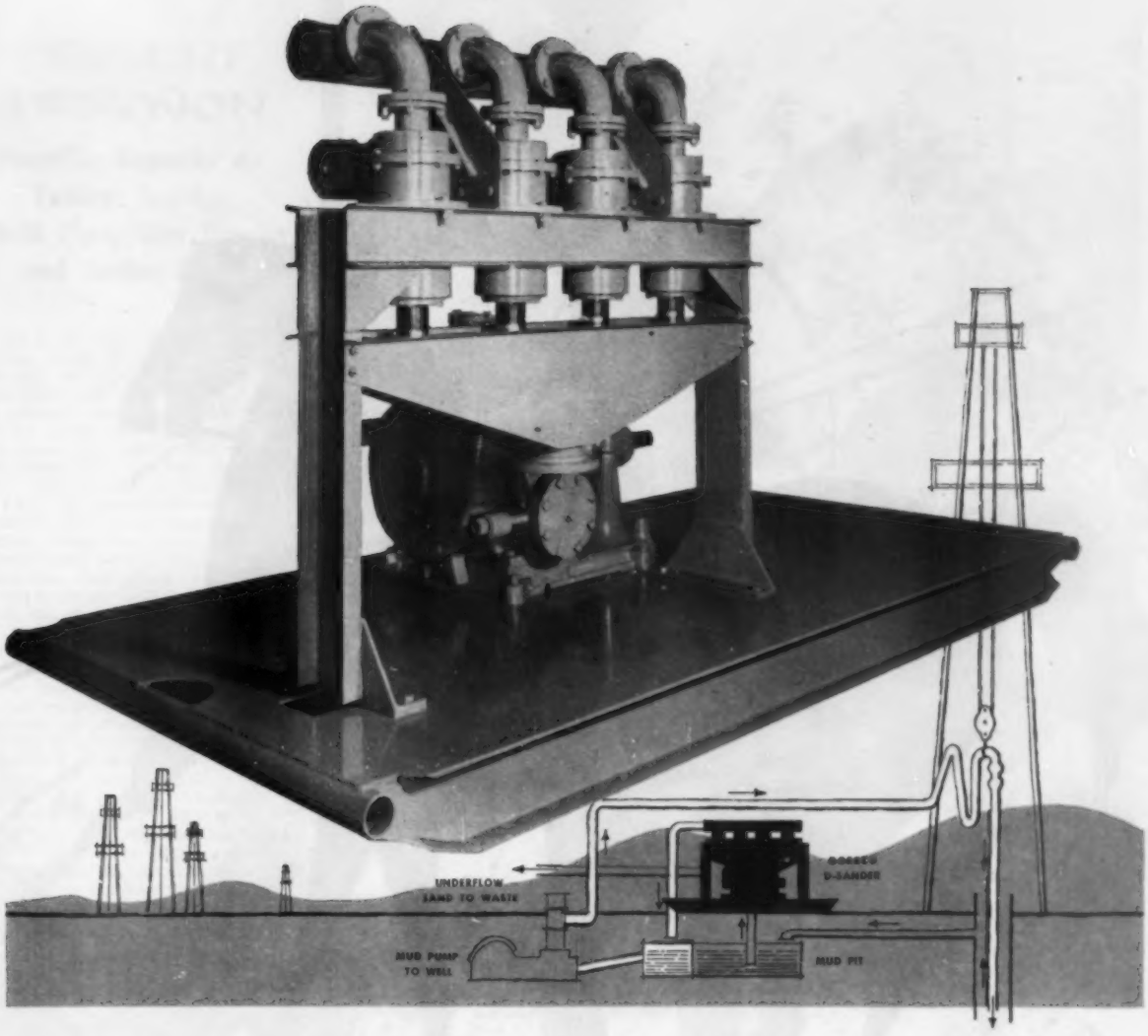
When the treatment is complete, the balls fall to the bottom of the bore hole where they can be left, or recovered easily with a bailer.

The new method is said to eliminate the expense brought on by drill-out operations. It is also unneccessary for the operator to rehire service equipment after it has been released from the first stage of fracturing or acidizing.

Records on one fracturing job in a West Texas oil field show the cost to the operator was $6400 using the normal proven fracture methods. Only a few locations from this job, a well producing from the same horizon, with approximately the same amount of effective pay was fractured by this method at a cost to the operator of only $4800. Both were multi-stage treatments.

The elimination of packers, bridge plugs used in previous methods, enables the operator to have more of the effective pay section treated. This results in a bigger potential and greater future production, especially in one interval which covers a long section.

One unit is now operating in the West Texas area performing Perforation Ball Sealer control jobs. All areas in which the company operates, including New Mexico, Kansas, and Oklahoma, were supplied with the service in September. ★ ★ ★



SIMPLIFIED MUD CONTROL

...with New Dorrco D-Sander

Solids build-up in drill muds is often aggravated by accumulation of hard-to-remove fine silty sands. This problem was solved in the Texas Panhandle by using a design variation of the proven Dorrco D-Sander. The new D-Sander, engineered specifically for *fine* or flour sand operations, will remove essentially all API sands and fine abrasive particles larger than 30 Microns. By removing undesirable solids from the drill mud system, mud weights can be closely controlled and aid in prevention of lost circulation.

In addition to maintaining lower mud weights, the Dorrco D-Sander will also reduce rig drill time, the number of bits used per well, and mud pump repairs.

U. S. Sales Representative for the Dorrco D-Sander: Salt Water Control Inc., 1211 Fort Worth National Bank Building, Fort Worth 2, Texas.

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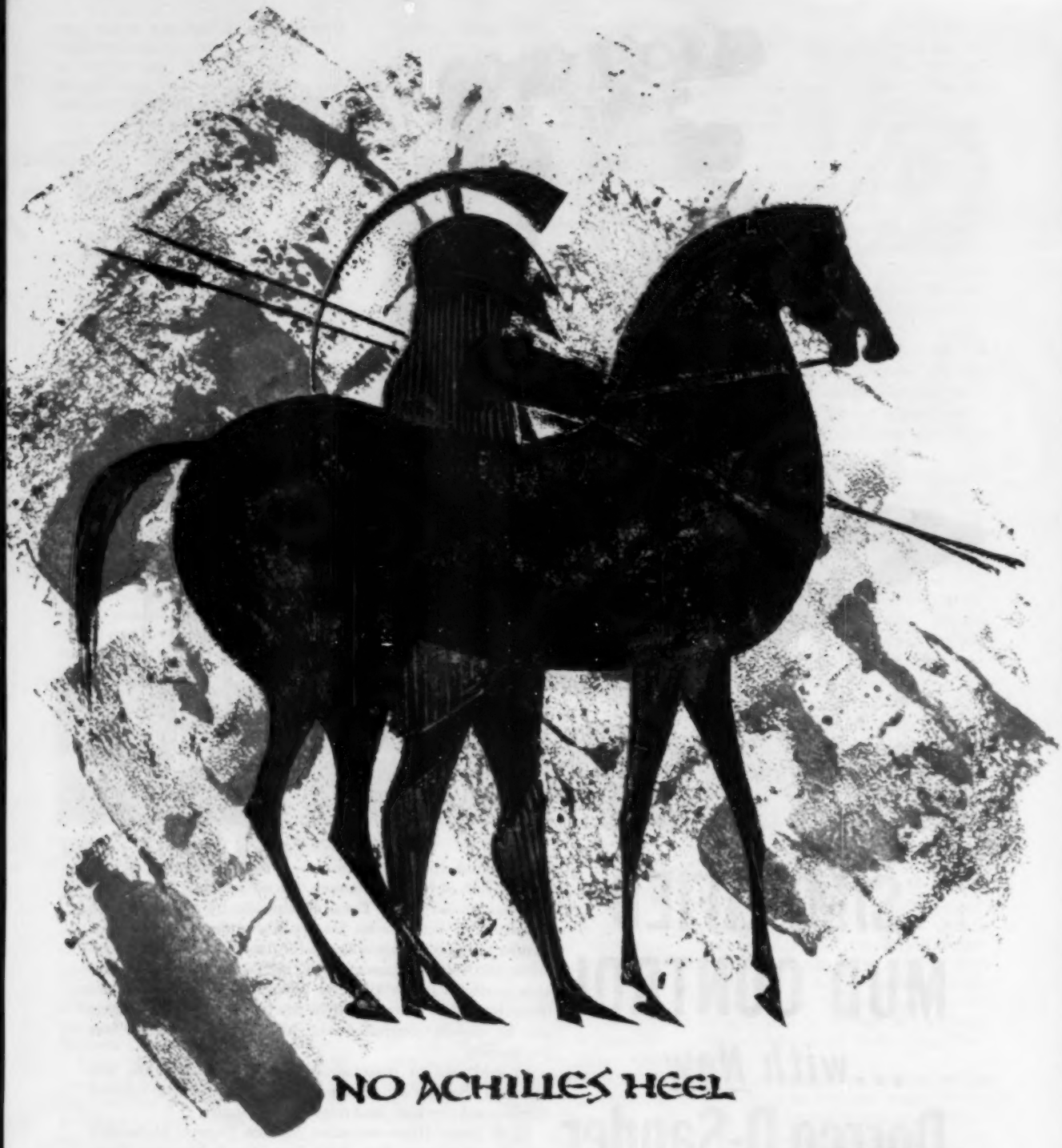

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TK-2 STANDARD KOTE – TO COMBAT CORROSION. This is a lining that resists both corrosion damage and paraffin deposition.

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Latest in wire line trucks is this new van type unit which is hydraulically powered and equipped with finger-tip controls for maximum safety and flexibility of operation.

Operator's control panel is simplified and consolidated for full control of the complete wire line operation. Wire line spool is under glass plate in front of control panel so operator can see complete well operation and wire line spool simultaneously.

Wire Line Truck Of the Future Now in Service

Field recommendations go into new streamlined, compact and flexible wire line service unit

A brand-new hydraulically-powered van type wire line unit was recently completed and placed into operation by Otis Pressure Control, Inc., of Dallas, Texas. It represents the latest developments in wire line units and incorporates many ideas forwarded from operators in the field. The wire line reel is hydraulically driven and can be removed easily from the truck by taking out four bolts. Most of the hydraulic lines and equipment are located in bins on the right side of the truck for easy accessibility.

An independent hydraulic brake system, apart from the main hydraulic system will lock and hold the wire line reel in case of an electrical failure, or if the switch should be tripped accidentally to the off position.

The control panel has been simplified for greater flexibility. Levers control the gears which drive the wire line reels and included in the control panel are two-way valves for emergency stops and upward jars by mechanical means. There is a remote control for pressure regulation, and a micro-switch for locking the hydraulic brake. By means of a hand wheel located inside the operators cab, the wire line is guided onto the spool. There are gages and controls for the hydraulic system and engine, including a tachometer, electronic weight indicator, wire line depth counter and throttle control. ★ ★ ★

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"Whale" Size Flexible Tanks Introduced in Oil Fields

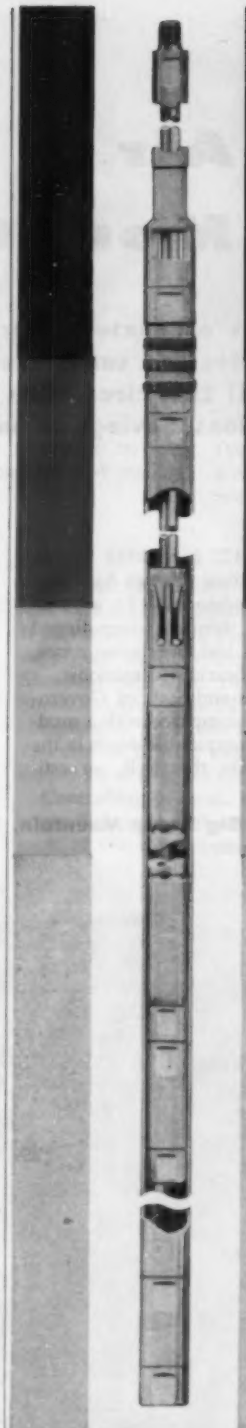
Transportation and storage problems in rugged terrain are being solved by collapsible rubber storage tanks used by Dowell Incorporated in its formation fracturing services. These tanks are being used in the Four Corners region of the San Juan Basin, where New Mexico, Arizona, Utah, and Colorado meet.

Rapid development of the oil and gas fields in the San Juan region provide the stimulus for the research, design and construction of these tanks. Engineers of Dow and The Firestone Tire and Rubber Company cooperated to introduce this new time — and money-saver to the petroleum industry. The tanks are an adaptation of the Firestone fuel cell developed for combat planes in World War II.

These rubber tanks, called whales by oil men, are constructed of rubberized nylon. They are strong, flexible, and oil and abrasion resistant. Each 15,000 gal tank, when filled, is 45 ft long, 11 ft wide and nearly 6 ft high. The new tank is intended to replace steel tanks for temporary storage of the water, crude and refined oils used in several well-stimulation processes.

Fracturing processes require the storage of large volumes of well-treating fluids at the well site. Transportation of large steel tanks for temporary storage is expensive and time consuming. The flexible rubber tank has proved to be an answer to the problem. Each tank with its piping and valves, weighs about 1350 lb. As many as six of them can be carried easily on a small truck equipped with simple hoisting gear to facilitate handling. These tanks can be rolled up like sleeping bags into neat, light weight packages less than 8 ft long by 2½ ft in diameter. Transporting them from well to well over rough country is a simple, inexpensive operation.

Several other interesting and unique features are incorporated into the tank. It has a lazy D shape and contains an internal system of flexible stabilizers or braces which prevents it from rolling, even on a 20 per cent grade. There is a built-in, pressure-release system which prevents rupturing the tank by overfilling and the tank can be filled or emptied at rates as high as 1680 gal (40 bbl) per minute. Each tank is supplied with a repair kit similar to a tire patching kit, a feature that makes on-the-job repairs possible and avoids the danger of explosions and fires which can occur when steel tanks are welded.



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One good way to lower your lifting costs is to run a Tuff-Temper pump. You can get them in all A.P.I. types, in heavy-duty models for deep wells, and in "stroke-thru" models for gyp and well trash. Leading stores throughout the Mid-Continent area carry Tuff-Temper pumps. Your local store, or our factory representative in your area, will be glad to give you additional details without obligation.

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Shell Oil Company's Experience in Drilling Five Shallow Wells

EXCLUSIVE

Drilling With Air In The Rocky Mountains

Problems encountered included: (1) Extremely hard carbonates and sandstones; (2) Steep-dipped formations; (3) Lost circulation zones, and (4) Water-bearing sections. Savings on one well estimated at $50,000

N. J. Isto, S. G. Stiles and S. C. Foster
Shell Oil Company, Denver Area

BETWEEN November 22, 1955, and March 10, 1956, Shell Oil Company's Casper Division drilled five exploratory wells with air as the circulating medium in Big Horn and Fremont counties, Wyoming. These are the first wells air-drilled by Shell in its Casper Division. Experience indicates that the use of air over mud through a dry penetrated section results in increased bit life and increased penetration rates. Use of air allows a continuous reliable evaluation of the penetrated section, and was recommended as a possible circulating medium when low reservoir pressures are anticipated. It was also determined from these initial tests that a critical amount of water entry can effectively stop the delivery of formation samples to the surface when employing air.

On two wells, removal of cuttings was improved by injecting one-barrel water "slugs" for each five feet drilled. It was determined also that there is an indication that increased rising velocity may contribute to increased penetration rates and that the so-called "optimum" value of 3000 ft per minute may not be valid in all cases. In selecting compressors for air-drilling based on minimum volume requirements, it was found that consideration should be given to the loss of compressor capacity due to down-time for repairs.

The first air-drilling test was in Shell's Government No. 1, on Big Sheep Mountain in Big Horn County, Wyoming. The remaining four wells were drilled on the Shoshone-Arapahoe leases in the Red Creek area of Fremont County. These were the No. 1, 141 Nos. 1 and 2, and 57 No. 2. These wildcats were completed as dry holes between November 22, 1955, and March 10, 1956.

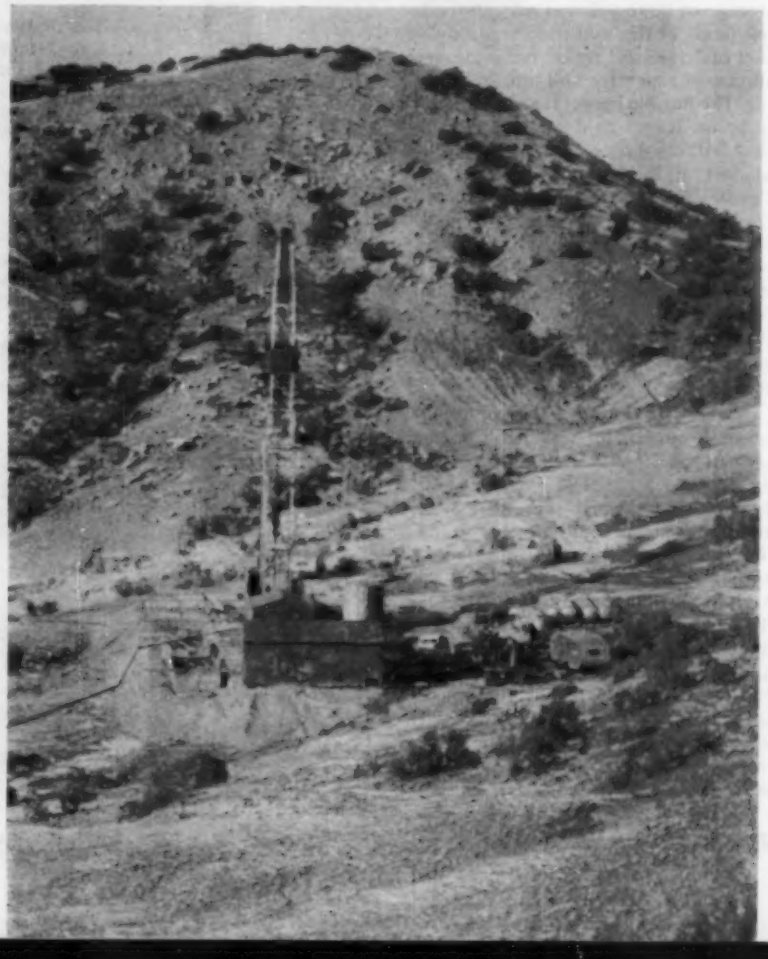
Drilling conditions common to each of these wells were (1) shallow depths ranging from 1422 ft to 2038 ft; (2) a penetrated section through hard carbonates and sandstones; (3) a penetrated section through steep-dipped formations; (4) lost circulation zones, and (5) water-bearing formations.

Drilling times and costs of Government No. 1 are compared with a mud-drilled well of comparable depth in the near vicinity. On this well, an estimated saving of $50,000 was realized. Similar comparisons are not available for the remaining air-drilled wells.

Why air was used. The choice of air as a circulating medium on Government No. 1 was based on:

(1) Surface geology indicated that the section to be penetrated was highly fractured. Air was used to eliminate the lost circulation

On slopes of Big Sheep Mountain, Shell's Government No. 1 is drilled to total depth with air.



Three 600 cfm compressors were employed to drill Shell's exploratory well on Big Sheep Mountain in Wyoming.

Two-stage angle compressor at right was used to regain circulation when surface pressure up to 300 psi was required.

expense that would have been experienced with mud.

(2) Under the existing winter and topographic conditions, hauling water for a mud drilled well would have been expensive.

(3) Increased penetration rates and bit life were anticipated with air through the extremely hard sections to be penetrated, a Mississippian-Ordovician interval.

These reasons were used to justify the use of air as a circulating medium in the four exploratory tests in the Red Creek area.

Rigs used. Small trailer-mounted rigs were employed to drill the five test wells. On Government No. 1 well, the rig consisted of a 95 ft mast, a drawworks rated at 230 input hp, driven by a single gas engine, and a separately powered pump. The four wells in the Red Creek area were drilled by a rig consisting basically of a 94-ft cantilever type mast with an 8-ft, 8-in. subbase, a drawworks rated at 250-hp input, powered by two 145-hp gas engines.

Government No. 1, Shoshone-Arapahoe 141 No. 2 and Shoshone-Arapahoe 57 No. 2 were completely drilled using air as a circulating medium; whereas, Shoshone-Arapahoe No. 1 and Shoeshone-Arapahoe 141 No. 1 were only partially drilled with air due to excessive water entry into the hole.

AIR DRILLING PROCEDURES

Drilling of Surface Hole

Previous to spudding, the cellar was dug and a short length of conductor pipe was cemented into place.

The surface holes were drilled with either two or three compressors to supply the air for drilling. Two compressors with sea level capacities of 600 cu ft per minute at 100 psig were used to supply air on Government No. 1. On Shoshone-Arapahoe 141 No. 2 and Shoshone-Arapahoe 57 No. 2, three compressors with sea level rating of 750 cfm at 275 psi were employed to supply air to drill the surface hole.

Controlling returns. Cuttings were controlled in a different manner on each of the three wells in which the surface hole was drilled with air. On Government No. 1 a 24-in. steel plate, cut to permit the kelly's vertical movement, rotated with the kelly on top of the conductor pipe deflecting the cuttings out the "blooie line." At Shoshone-Arapahoe 141 No. 2 a 16-in. diameter steel plate with an 8-in. hole was welded to a large casing collar which served as a stabilizing skirt to fit over the conductor pipe. On top of this collar and plate, two steel split plates and a rubber drill pipe wiper were attached with cap screws. Neither of these devices were completely satisfactory; however, the latter was the most effective in controlling the dust and cuttings. At Arapahoe No. 2 a rotating blowout preventer was flanged to the conductor pipe, and though more expensive and time consuming, it completely eliminated the dust problem in the rig working area.

Cementing practices. Normal cementing practices were employed on the surface casing in wells in the Red Creek area. Because of extreme porosity on Government No. 1, where surface was cemented at 67 ft, ready-mixed cement was used. The cement was poured around the surface casing and tamped into place.

Gas detector trap, mounted on legs in foreground, connects to a 6⅝-in. "blooie line."

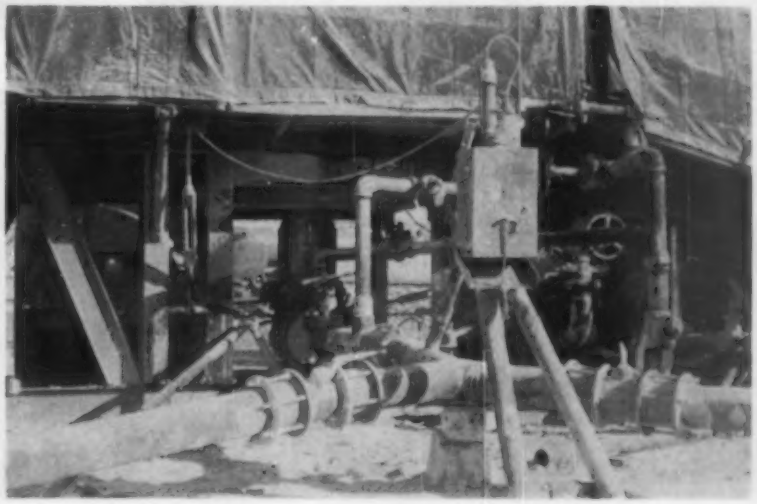
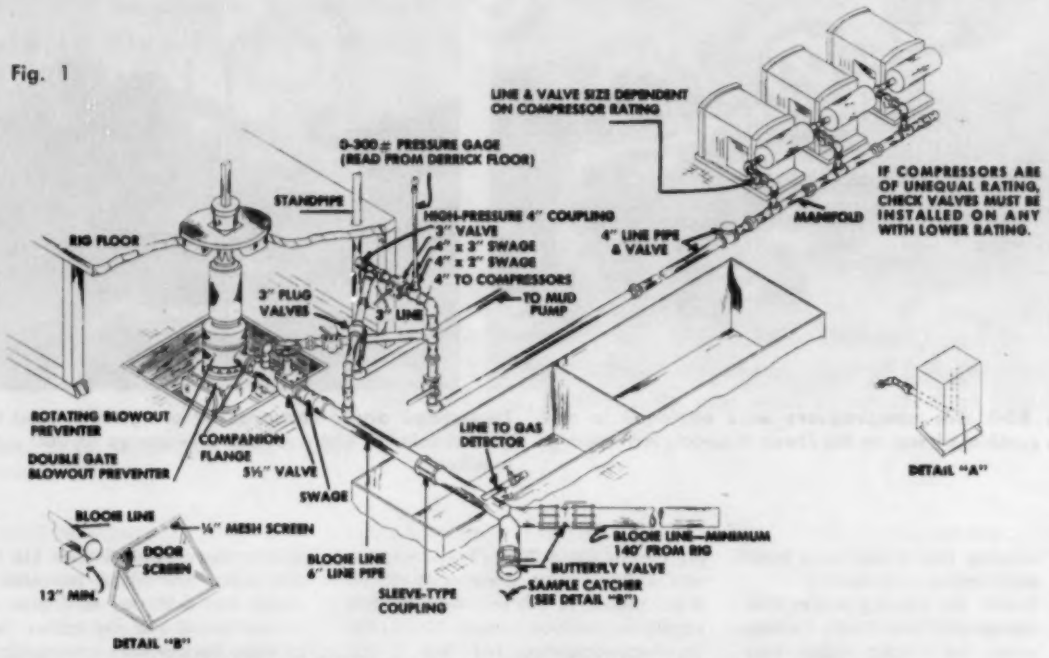


Fig. 1



Air drilling installation, shown in schematic form, of special equipment used to drill five exploratory wells in Wyoming.

Drilling Below Surface Casing

Prior to drilling out of the surface casing, a rotating blowout preventer, a 10-in. series 900 blowout preventer, and 10-in. casing head housing were installed in series above the surface casing. The function of the rotating blowout preventer was to control possible flows of gas, oil, or water and to divert the cuttings and dust to the "blooie line."

Three 600 cfm compressors ordinarily supplied enough air for drilling below the surface casing. During part of the drilling operations at Government No. 1 an additional compressor was used. When this additional compressor capacity was applied, an increase in penetration rate was generally noted. In one extreme case, the rate increased from 6 ft per hour to 30 ft per hour. On Shoshone-Arapahoe No. 1, which was only partially drilled with air, four compressors were used. Three compressors each with a rated capacity of 600 cfm at 100 psi were used to air-drill Shoshone-Arapahoe 141 No. 1. Three compressors were used to supply air for drilling the two additional tests in the Red Creek area.

Loss of returns. When the surface casing was cemented using normal oil field cementing procedures, air was circulated until the hole was dry before drilling out of the shoe. Cuttings ceased coming to the surface at some time during the drilling period of all wells drilled with air. In Government No. 1, water in the hole was believed to be the cause for failure of cuttings to return to the surface. Air drilling was continued when the cuttings failed to return to the surface and no harmful effects were experienced.

Air as a circulating medium was discontinued in Shoshone-Arapahoe No. 1 and Shoshone-Arapahoe 141 No. 1 because of excessive water entry into the hole. In attempting to regain circulation, the standpipe pressure reached the maximum discharge pressure of the compressors. This problem was overcome on Government No. 1 by stage circulating after each stand was run in the hole on a trip. Sufficient water, however, had entered the holes in Shoshone-Arapahoe No. 1 and Shoshone-Arapahoe 141 No. 1 to cause the pressure to increase above the discharge pressure of the compressor after making a connection.

AIR DRILLING TECHNIQUES

Installation of Equipment Needed

On the original installation, it was recommended that as much of the air hookup as possible be fabricated. On Shell Government No. 1, a 4-man roustabout crew, a welder, and a truck with an A-frame and winch were employed while rigging up. They required a total of 120 man-hours to fabricate completely and hook up the air system. If the drilling crew is busy flanging up, a contract roustabout crew can be employed economically in order to eliminate down time of the drilling rig.

"Blooie line." Normally, the "blooie line" was laid through the substructure under the "V" door. The "blooie line" was usually constructed of 6⅝-in. line pipe laid to a distance of about 200 ft from the rig. Considerable trouble was encountered in laying the "blooie line" over rough terrain because of its weight. Therefore, it was recommended that a bulldozer cut a smooth path off to the side of the rig to facilitate construction of the "blooie line."

Surface air supply system. The manifold receiving air from individual compressors should contain a swing check valve as shown in Fig. 1. This is necessary to protect the compressors in the event the well kicks or fluid enters the manifold line for any other reason.

A check valve is necessary on the line leading from any lower pressure rated compressor to the manifold. During connections and trips when the air valve at the standpipe is closed, a com-

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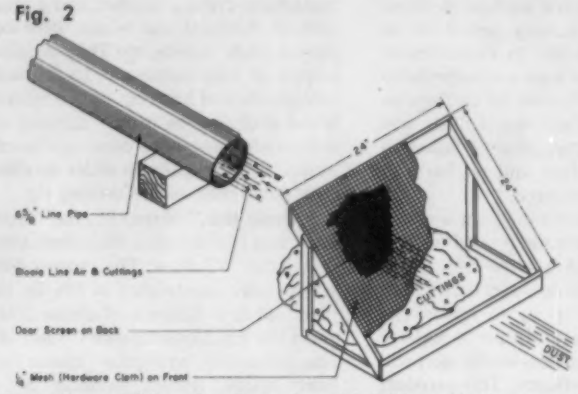
Fig. 2



Sample catching hookup for air drilling. Cuttings were blown through a ¼-in. mesh screen. Samples varied from microscopic to dime size.

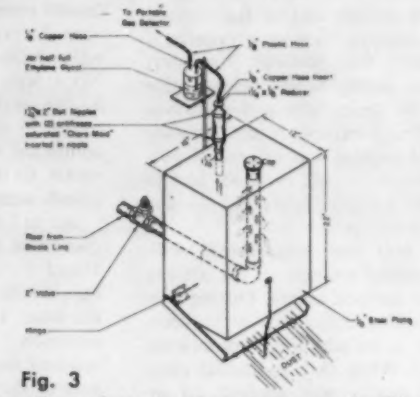


Fig. 3

Detection of gas in return stream was by this special designed air-gas trap setup connected to riser in "blooie line."

pressor idling at a higher pressure would continually "pop" the volume tanks of compressors idling at a lower pressure. (See Fig. 1.)

If reverse lines are not employed as shown in Fig. 1, the necessary fittings should be installed while rigging up to allow the air supply line to be bled off during connections.

The surface air supply system was assembled in a similar manner on the five wells drilled with air by Shell in the Casper Division.

Landing surface casing. The surface casing should be landed at a point so that subsequent addition of the casing head housing, blowout preventers and rotating blowout equipment will allow the "blooie line" to be attached to the rotating blowout equipment near ground level. This eliminates unnecessary welds and bends in the "blooie line."

Surface Pressure

While drilling, standpipe pressures ranged from 60 psi to 110 psi. In attempting to regain circulation in two of the wells, however, pressures of 180 psi were encountered which is the maximum discharge pressure of the 600 cfm air compressors.

Where compressors of higher discharge pressures were used exclusively on Shoshone-Arapahoe 141 No. 2 and Shoshone-Arapahoe 57 No. 2, standpipe pressures ranged from 60 psi to 300 psi. The latter pressure was required when attempting to establish circulation.

Air Volumes and Rising Velocities

No attempt will be made in this report to elaborate on the formulas and theories for determining minimum air requirements. Reference is made to two suggested methods, however.

In the June, 1954, issue of *The Petroleum Engineer* an article appeared entitled "Air and Gas Drilling" by K. M. Nicolson, Standard Oil Company of California. In this article a relationship was developed between air velocity, air density, particle shape, and particle size lifting capacity to express the slip velocity of a sphere in a fluid. From this relationship, graphs were prepared to determine the air volume requirements for lifting an assumed rock particle size. Graphs are shown for particle sizes ranging from ⅛ in. in diameter to ¾ in. in diameter. In addition to assuming the size particle to be lifted, a knowledge of the hole depth, hole size, drill pipe size, specific gravity of the circulating medium, and bottom hole temperature are needed. Nicolson's article also appears in *Drilling and Production Practice*, American Petroleum Institute, 1953 edition. This article is highly recommended for those interested in air drilling.

A second method for determining volumetric requirements appears in the January and February, 1955, issue of *World Oil*. From a derivation of the Weymouth flow formula, Philip L. McLaughlin, formerly drilling editor and author, developed charts and graphs showing volumetric requirements assuming annular velocity of the air at the point of lowest velocity in the annulus equivalent in lifting power to 3000 ft per minute of free air. This minimum rising velocity is a "rule of thumb" and has been established from field experience in quarry work. Conditions needed for application of these charts and graphs are: Hole depth, hole size, drill pipe size, and the specific gravity of the circulating medium.

Air volumes calculated from the previously mentioned formulas are based on minimum requirements. In the five tests drilled, minimum air volume requirements were well satisfied at all times. Volumes ranged from 1575 cfm to 2552 cfm with rising celocities respectively ranging from 4730 ft per minute to 10,580 ft per minute.

Penetration Rates

The average penetration rates ranged from 11.3 ft per hour to 16.1 ft per hour. In Shoshone-Arapahoe 57 No. 2 at the point where water was encountered, penetration rates decreased 55 per cent.

In general, it appears that penetration rates varied proportionally with rising velocities. In Shoshone-Arapahoe No. 1, the penetration rates decreased from 20 ft per hour to approximately 12 ft per hour with a decrease in rising velocity from 7150 ft per minute to 556 ft per minute. An increase in rising velocity from 5560 ft per minute to 6960 ft per minute resulted in an increase in penetration rates from 12 ft per hour to 20 ft per hour. These variations occurred in the Phosphoria and Tensleep sections which are comparable as far as drillability is concerned. This would indicate that in the drilling of these holes the optimum rising velocity was not 3000 ft per minute but some higher value.

Bits

In the majority of cases, ¾-in. jets were used in bits drilling surface hole and 11/16-in. jets were employed in the bits drilling below the surface casing.

It was first believed that the high pressure drop through the nozzles of the jet bits would cause a loss of air volume. As a result, the material between the water courses of several of the bits was bored out to provide a larger circulation opening. However, no pressure decrease was indicated on

the pressure gages when using these full opening bits.

Bit Weight and Rotating Speed

Although weight on bit was varied from 8000 lb to 35,000 lb in drilling below the surface casing, the average weight on bit was approximately 25,000 lb. The bits were rotated from 60 revolutions per minute, to as high as 150 revolutions per minute.

In the Red Creek area the best results were obtained with 25,000 lb on the bit and a rotating speed varying from 65 to 90 revolutions per minute.

Deviation

No difficulty was experienced due to hole deviation from the use of air as a circulating medium. In Shoshone-Arapahoe 141 No. 2, deviations of as much as 17 degrees from the vertical were experienced; however, this drift was probably due to faults and formations dips as high as 53 degrees.

A stabilizer was used in drilling part of one well but was removed to permit more efficient removal of cuttings.

Samples

Drilling samples obtained were excellent for microscopic description. These samples ranged from dust particles to dime-sized cuttings. The most satisfactory method of catching samples consisted of putting a ¼-in. mesh screen in front of the "blooie line", as shown in Fig. 2.

In order to obtain samples after water was encountered in the hole, ½ to 1 bbl of water was injected for each 5 ft drilled. The injected water carried the cuttings to the surface resulting in excellent sample recovery.

Gas Detector

The gas detector air-gas trap shown in Fig. 3 was designed and assembled for use on air drilled wells. The trap proved to be a successful replacement for the conventional mud-gas trap. It operated satisfactorily in diverting low concentration gas in the air return line ("blooie line") for pickup by the detector unit compressor. A quart of gasoline poured into the drill pipe during connections was a satisfactory sensitivity check of the gas trap and detector equipment.

The same method of gas detection was used in all Shell's attempts at air drilling in the Casper Division.

In the following cost comparison it should be pointed out that lost circulation did not present a problem on Great Western Sugar Company No. 1 while drilling the section under consideration. If mud had been used as a circulating medium on Shell Government No. 1, the cost of combating the known lost circulation zone would have been exceedingly high. It is estimated that a savings of at least $50,000 was realized through the use of air as a circulating medium on Government No. 1. ★ ★

Available Comparisons Between Air and Mud Drilling

Drilling times and drilling costs of Shell's air drilled Government No. 1, Big Sheep Mountain are compared with a well drilled with mud in 1952, Great Western Sugar Company No. 1 located approximately three miles to the northwest. Both sections penetrated were geologically similar.

Drilling Time Comparison

	Shell Gov't. No. 1 Big Sheep Mtn. Air Drilled	Great Western Sugar Co. No. 1 Big Sheep Mtn. Mud Drilled	Per cent Improvement of Air Drilled Well
Comparable footage drilled	1422 ft	1431 ft	
Over-all hrs. (Spud to comparable footage drilled)	236	705	67% Decrease
Total rotating hrs. (Includes drilling, coring, and reaming)	131	431	70% Decrease
Rotating hrs. while drilling	125½	316	60% Decrease
Number of bits	9	24	62% Decrease
Average feet per bit	158	59.6	265% Decrease
Average penetration rate (Total rotating hrs.)	10.9 ft/hr	3.3 ft/hr	327% Increase
Average penetration rate (rotating hrs. while drilling)	11.3 ft/hr	4.5 ft/hr	250% Increase

Cost Comparison

The comparison includes only those costs which compare mud and air drilling.

	Shell Government No. 1 (Air Drilled)	Great Western Sugar Co. No. 1 (Mud Drilled)
Day work drilling	$ 7,900	$23,700
Bits	1,685	5,485
Compressors, operators, and fuel	5,250	0
Rotating B.O.P. equipment	500	0
Diamond bits	0	3,700
Water, mud, and additives	0	1,500
Water pump and installation	0	1,500
Miscellaneous	1,000	0
Total	$16,335	$35,885
	Savings—$19,550	

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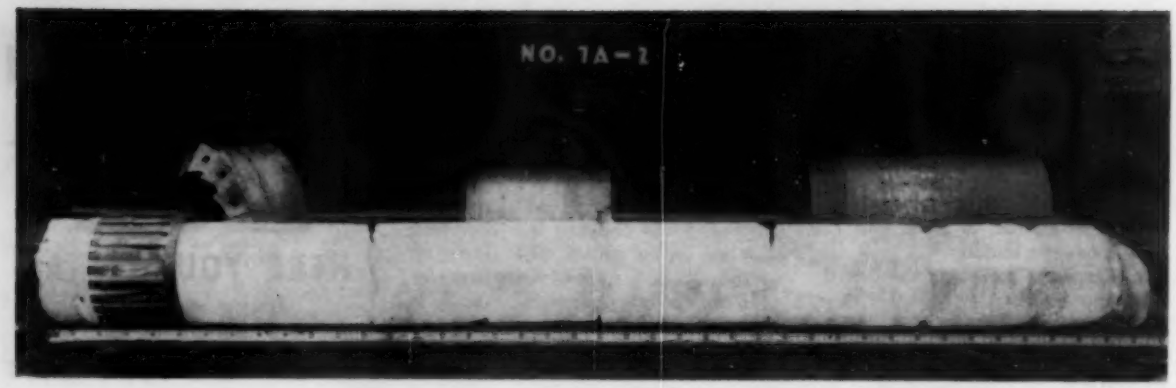


Ice core samples taken from the Greenland ice cap. The core lifter is on the core at the extreme left. Next to it is the special core bit developed for the ice project. Also above the core is the inner tube extension of the core barrel and the blank reaming shell.

Army turns to oil industry to uncover Greenland's frozen secrets

Core Drilling On the Polar Ice Cap

Engineers hope to solve geological and weather problems using specially designed air drilling rig and coring equipment

FOR years, weather experts and scientists have been wondering what effect Greenland's tremendous mile-thick ice cap has had — and will have — on weather conditions around the world. Now they plan to find out.

Using a special core drill, somewhat similar to those used in oil fields, U. S. Army engineers are boring deep into Greenland's ice covering hoping to come up with the answers to lots of perplexing weather questions.

For instance, they hope to learn:

1. The temperature of the ice cap at various depths.

2. Information on the various weather cycles over the past 1000 years.

3. What Greenland was like before it was covered by ice.

4. Data on wind currents of years back from particles of volcanic ash and dust inbedded in the ice cap.

5. Some estimate of the ice cap's effect on world weather conditions during the past, present, and into the future.

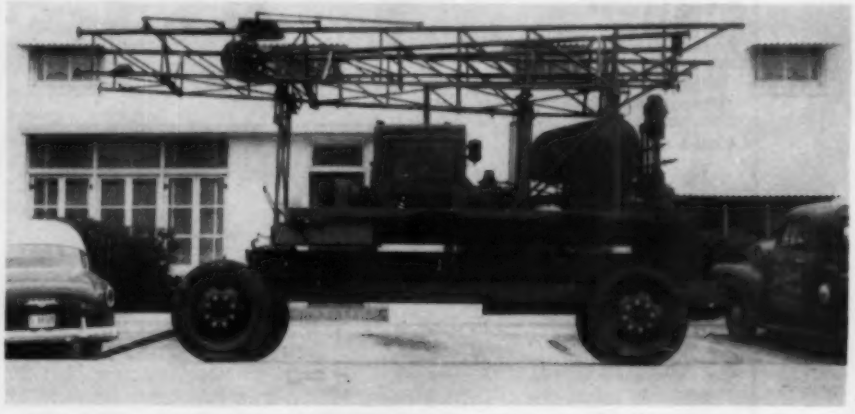
The operation — which is linked with various other projects in the International Geophysical Year — has just begun.

The work is being done at an altitude of about 7000 ft above sea level and average surface temperatures are about 20 deg above zero.

Since this will be the first time a serious and planned effort has been made in this direction, engineers and others connected with the project are reluctant to predict the end results. They do say, however, that it is hoped that this year's coring operation will produce sufficient results to justify the larger-scale operation that has been set up for 1957.

The project calls for cores 4 in. in diameter through the ice. Special bits have been produced for this work by the Failing Company working jointly with the Snow Ice and Permafrost Reseach Establishment (SIPRE). Other items of equipment include specially designed core barrels and core lifters.

All drilling is being done with air



Rotary core drilling rig is skid mounted and specially designed to operate at about 20 F average surface temperature.

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the radically new

MODEL 63

BOTTOM DISCHARGE VALVE

On demonstration during October

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Fitted with a flexible and resilient ball guide, the PACIFIC Patented* API Ball Valve Cage lowers your production costs by—

1 Extending the use life of ball valve and cage.

2 Extending the runs between pulling the pump to replace worn valves, seats and cages.

Why a flexible, resilient Ball Guide?

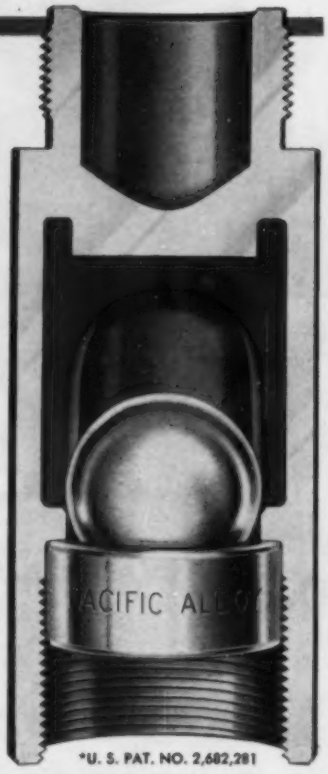
The difference in the capability of a resilient and a rigid material to absorb repeated shocks without permanent deformation is shown graphically by the unretouched photographs below. The ball valve cages are from the same pump.

HERE IS THE ANSWER:

The PACIFIC steel ball valve cage, with a flexible, resilient ball valve guide bonded to the cage, *costs no more* than a standard steel ball valve cage, *yet it will give three to four times the service.*

A PACIFIC steel ball valve cage fitted with a flexible, resilient ball valve guide retains its original shape after 182 days of continuous operation. The ball valve is in good condition and may be easily removed from the cage.

A standard steel ball valve cage with hardened steel ball valve guides permanently deformed after 49 days of continuous operation. The ball valve cannot be removed from the cage.



*U. S. PAT. NO. 2,682,281

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pw16

which is compressed to 100 psi. After the air has been compressed, it is run through an air-to-air heat exchanger which lowers the temperature to ambient-plus 10-deg. Then the air goes through a receiver tank where a large percentage of the moisture, condensed by the drop in temperature, is removed due to the velocity drop in the air stream. From this point it is directed to the air turbine for further cooling and at this point the air reaches the approximate temperature of the ice. From the air turbine the air is directed into the drill string. (To record the temperature in the ice cap successfully it is necessary that the temperature of the air used in drilling be the same as the temperature of the hole.)

The Army has designated the work site as Site 2, located on the 83rd parallel — only a hop, skip, and a jump from the North Pole. The 20 members of the engineering team are living in huts 25 ft under the snow-covered terrain.

The drilling is being performed with a skid-mounted Failing model 314 core drill unit built according to Army specifications. The equipment was flown from the United States to the Air Force's base at Thule, Greenland, and then transported the last 200 miles by cat-train.

The Greenland ice cap — which is believed to hold a number of unusual weather and geological secrets — presents a real challenge to the Army's Engineering Corps.

Greenland, which is the world's largest island, is 600 miles wide and 1600 miles long. Four-fifths of Greenland's surface is covered by the ice cap which is estimated to be as much as 10,000 ft thick at its center. Altogether, the ice cap measures 647,800 cubic miles. Some explorers have stated that if Greenland's ice cap were spread evenly around the globe the entire world would be enveloped by an icy blanket approximately 17 ft in thickness.

The tremendous power of Greenland's ice cap has been shown in previous surveys which disclosed that the ice cap drains its ice into Disko Bay through glaciers — and that some of these glaciers have carved out canyons 30 miles wide and 300 to 1200 ft below sea level.

The core drilling operations are headed by G. R. Lange, project engineer, and the team includes drillers, geologists, glaciologists and other engineers and scientists. Last year, Lange spent several months with a core drill in the permafrost area, around Churchill, Manitoba, Canada.

The entire project is under the supervision of James E. Gillis, director of the Snow, Ice and Permafrost Research Laboratory at Wilmette, Illinois.

★ ★ ★

Reports from everywhere prove–Rockwell Built

MUDWONDER Outworks, Outlasts ANY OTHER MUD VALVE!

You, like S. T. "Buck" Dotson (above), toolpusher on Big Chief Drilling Company, Rig. No. 32, will be convinced that your best mud valve buy is MUDWONDER once you've tried it.

Here is a mud valve that was designed, built, and sold for one purpose—to handle oil drilling muds efficiently and economically regardless of the sand content or lost circulation material. It's a big order, but MUDWONDER valves take it in stride.

Big Chief was one of the drilling companies selected to do the original MUDWONDER field testing several years ago. The crew members of Rig. No. 29 on which the test valve was installed were told to use, abuse, and prove the MUDWONDER on their toughest service.

Now, reports from all over the U.S.—overseas, too—prove that MUDWONDER valves can take harsh treatment and still outperform, outlast other mud valves.

That's why every contractor and toolpusher who has tried the MUDWONDER insists new rigs be equipped with MUDWONDERS and old rigs have MUDWONDER replacements.

Edward Valves, Inc.

Here's your proof ···▸

Competitively-Priced MUDWONDER

Rockwell Built

MUDWONDER Stopped Standpipe Valve Sanding-Up On Falcon Seaboard Rig #29

"Our 4-in. MUDWONDER has more than paid for itself with savings in down-time and parts on these last four wells," says toolpusher E. A. "Blackie" Blackwell, "and it is still working perfectly—holding pressure as well as the day we put it on."

In the Anse Le Bute and Church Point fields where the Falcon-Seaboard Drilling Company Rig No. 29 has been working, sand is quite a problem. According to "Blackie" de-sanding the standpipe valve at least once every hole and replacing parts was a necessary and costly practice until he bought a MUDWONDER for the standpipe.

Now "four holes" old, the MUDWONDER has required no maintenance and still works easily and positively. Even if it should need a part replacement in the near future, the job can be done quickly and easily. The one-piece MUDWONDER body stays in the line and only one wrench is needed to remove the bonnet.

Rockwell Built

MUDWONDER Completes 24 Cementing Jobs Without Downtime on *McCall Rig*

"Without a doubt the toughest mud valve job on our rig is the standpipe opening we use for bleeding and cementing," comments W. W. "Bill" Sauer, toolpusher, Gabe McCall Drilling Company, Tioga, North Dakota. "There is where we put our first Rockwell-Built MUDWONDER almost a year ago. We have just completed our 24th cementing job through this amazing valve and our books show that the original gate and insert are still in the valve. Previous records for inserts in this service were from 4 to 6 jobs.

When we bleed off our standpipe we have over 2000 psi pressure. Our 2-in. Fig. 3128, 3000 psi WP (6000 psi test) MUDWONDER always operates easily.

"Since we first tried the MUDWONDER we have put them on our jet guns and mud manifold with equal success. Needless to say, we plan to replace the entire mud system with MUDWONDER valves as replacements become necessary."

Edward Valves, Inc.

Beats Other Valves In Mudline Service

Rockwell Built

MUDWONDER Cuts High Maintenance Costs To Zero In Jet Service *on Delta Gulf Rig #5*

"We have drilled 45,000 ft. of hold since equipping our jet guns with 2-in. MUDWONDER mud valves," says toolpusher W. M. "Mack" Ault. "These valves have been in constant service, operated under extreme pressures on fluids containing as much as eight per cent sand and at times as much as 12 lb. per barrel lost circulation material. They have required no maintenance and have operated with ease at all pressures."

The cost of maintaining mud valves, especially the jet or mud gun valves, had reached an alarming figure on the Delta Gulf Drilling Company Rig No. 5 working in the Lake Charles, Louisiana, area. According to "Mack" MUDWONDER valves are just what has been needed for a long time in the oil field to help reduce operating costs.

Is it any wonder "Mack's" crew feels MUDWONDER valves can cure any mud valve problem? MUDWONDER has licked their worst.

Rockwell Built

MUDWONDER MUD Valves Record Two Years On Durham Rig Mudlines *with Zero Maintenance*

J. W. "Bill" Hall, drilling superintendent, Durham Drilling Co., Midland, Texas, reported, "For the past two years I have been using Rockwell-Built MUDWONDER mudline valves as replacements on our rigs. They are in service on jet guns, mud manifolds, fill-up lines and standpipes . . . and, have given trouble-free operation under all conditions. In the two years since we started using MUDWONDER valves, our maintenance costs on them have been 'zero' because no parts have been replaced.

"When deciding on equipment for the new rig, we checked our MUDWONDER records which left no doubt about the valve to use.

"Freedom from maintenance is most important but easy operation is another MUDWONDER feature that makes a hit on our rigs. Regardless of pressure or position of the MUDWONDER, it opens or closes quick and easy. We never need a cheater."

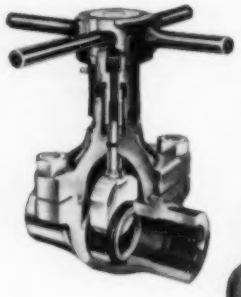
Here's what you get

Why The MUDWONDER Gives Mud Valve Economy

A hard chrome gate which is separate from the stainless steel stem plus a buna-N(Hycar) seat insert integrally molded over steel wear rings combine to resist abrasion—give long, dependable service.

In addition MUDWONDER provides seven other big operating advantages:

- **Keeps mudlines intact**
- **Operates easier, faster**
- **Seals drop tight**
- **Stops sanding**
- **Cuts maintenance**
- **Slashes downtime**
- **Assembles easily**



EASY TO INSTALL... EASIER TO MAINTAIN

Longer wearing parts which can be replaced easily and quickly are causing the big switch to Rockwell Built MUDWONDER by cost-conscious drillers.

Whenever maintenance is needed, the operation is simple. Bonnet assembly lifts off without disturbing the mudline hook-up.

Inspection or part replacement, if necessary, can be made while the crew is making a connection. Extra seats and, perhaps, a gate for each size—both are interchangeable between pressure classes—are all the parts inventory you should need.

Drilling men have tried MUDWONDER—even abused it—to prove its economical superiority for installation, operation and maintenance. As a result, drilling men everywhere are replacing troublesome mud valves with MUDWONDER.

Ask your favorite oil field supply store for complete information, or write, call, wire Edward Valves, Inc., East Chicago, Indiana. Shipments are made from East Chicago or the Edward Houston warehouse at 1606 Maury St. through the supply store you select.

Here is the wear-absorbing heart of the MUDWONDER. Hard-chromed gate in combination with buna-N seat molded integrally over steel wear rings resist abrasion.

Edward Valves, Inc.
Subsidiary of
ROCKWELL MANUFACTURING COMPANY
1492 West 145th Street
EAST CHICAGO, INDIANA

Send me your latest MUDWONDER catalog and price list for 3000 psi WP (6000 psi test) and 2000 psi WP (4000 psi test) mudline valves.

Name_____

Company_____ Title_____

Address_____

City_____ Zone_____ State_____

Rigging up and tearing down a rig is unusually hazardous because of the additional manpower required and the infrequency of the job. In above photo, crew is adding crown block to mast prior to raising.

P 420.31

Safety in Rigging Up And Tearing Down

Operational standards of safety cannot be packed away on rig moving day; efficiency cannot be traded for momentary expediency. Check the list of safe practices on your next move

J. L. Muir
Safety Director, General Petroleums of Canada, Ltd.
Edmonton, Alberta, Canada

MANY of the well-known sayings and slang expressions we use in the oil industry are a detriment to safety right from the beginning.

Even part of the heading of this paper is unsafe. "Tearing down," while it simply means the act of dismantling a drilling rig, has unpleasant implications. We can make a start in thinking in terms of safety by substituting the word "dismantling" for "tearing down."

In either dismantling or rigging up operations, the crew enters a phase of work that is not daily routine. Since the crew is not in the position of being in continuous practice when these jobs come along, they are necessarily in the category of being "green hands." It is, therefore, especially important that conscious effort should be made to make these operations safe.

Essentially, the two operations involve taking a whole manufacturing plant apart and putting it together again within a very short time. Since rig parts and equipment must be compact, yet powerful, they become very heavy and unwieldy. Because of this fact, and because they become unbolted and unstationary, it is easy to forget all the points used in the everyday drilling program to bring about efficiency and safety. Safety is only a part of efficiency, and where you have optimum efficiency, you are bound to have 100 per cent safety.

Working Together

One of the first essentials of efficient operations is teamwork. We achieve that readily — if we want to — when we are working our daily tour on the rig floor. But when we are moving a rig, we then have an enlarged team suddenly thrown together. Although we may know our teammates personally, as individuals, we are now compelled to work together as a team that has not had any practice before entering the game. Each of us is more or less placed in the position of having to share our work, having to help the other fellow to do his, and perhaps having to accept orders from one who does not usually give them. It is part of human nature to offer some resistance to this condition. Regardless of this fact, it is vitally necessary to achieve cooperation, to work together as a skilled and drilled team.

First Things First

A second point to be stressed is that of planning. Advance plans must include a well-mapped route from one location to another, a careful schedule, and decisions on each man's duty.

If the move is not well planned in advance, the result will be unnecessary lost time and physical hazards. For example, here are some of the results of confusion:

- Time is lost when drivers must wait to have their trucks loaded to carry pipe and equipment to the new location.
- If no provision is made for systematic unloading of parts at the new location, the trucks must either wait until help arrives, or else the equipment is unloaded on the ground only to be handled all over again.
- When plans are not made in advance for racking pipe at the new site, several time-wasting and unsafe conditions may occur. The pipe may be dumped on the ground (and "dumped" is unfortunately the right word). Any available planks, instead of the proper unloading ramp, may be used to roll the pipe off the truck, an extremely dangerous practice. Some trucks may carry pipe, while others carry the pipe racks, which do not arrive in time to be used. If there are a few pipe racks, but not enough, at the new location, the crews may overload them with too much pipe.
- The derrick may arrive at the new location before the substructure, leav-

Unloading heavy-duty drilling equipment takes special equipment and special precautions. Above, crew takes off compound and engines from truck onto substructure.

ing insufficient room for mobility of trucks carrying heavy loads of large parts.

All these hazards and wasteful conditions can be avoided by systematic planning to set up the racks in advance, and to move in the pipe and equipment in sequence in which they will be used in rigging up.

Safety Equipment — Use It

A third important point in dismantling and rigging up operations is the use of safety equipment. Most contractors and operators provide good safety equipment, but it does no good if it is not used by the crew.

For a crewman, use of safety equipment should become as automatic as breathing — and whether or not he continues to breathe may depend on it.

It is a job of constant education to teach the men to use the tools of safety, and in a safe manner. How many men wear safety belts when working on the girts in the mast? How many carry hand tools properly when climbing the derrick? How many toes have been lost through failure to wear safety boots?

There is often an objection to donning personal safety equipment for a job that takes only a minute . . . but it does not take even a minute to have an accident, only a second.

Direct Traffic

A fourth point, and most important in this phase of operations, is supervision. It is vitally important that a supervisor stand by to direct traffic, as well as the actual work operations.

Where a man stands may be where he falls, if he is standing in the wrong place. I have seen men standing in a position where, had the truck winch line snapped, a serious or fatal accident might have occurred. Lines do break, sometimes, as we all regretfully know. It is the supervisor's responsibility to make every effort to keep his men clear of such hazards.

The matter of extra men on the team was mentioned previously. With these men, and with all the extra equipment in use during dismantling and rigging up, it is especially important that the supervisor take extra care to see that no man is in the wrong place at the wrong time.

Mast Erection Check

Another point concerns the most dangerous phase of rig moving: Raising and lowering the mast. When this job is handled efficiently, it can be carried out without the slightest hazard to men or material. The plan is itemized in the following list of check points:

RAISING AND LOWERING DERRICKS

- ☐ 1. Always completely warm up motors and check to be sure there is sufficient fuel.
- ☐ 2. Check brakes, pins, shoes (if necessary burn brakes in case there is oil on same.)
- ☐ 3. Check to see that no material is under the derrick leg which will prevent it from turning inside the shoe and so stopping that rig from turning freely in the shoe thereby causing the mast to twist beyond its allowable stress and strain and so cause it to collapse. Ice is one enemy we have that can cause such a condition.
- ☐ 4. Check clutches for sticking. (Use positive clutch in low gear with all motors.)
- ☐ 5. Have experienced man on manual-operated throttle in case air throttle sticks.
- ☐ 6. Keep crown end of derrick up level with the substructure to decrease strain on derrick on the initial lift.
- ☐ 7. Visual check of all toggles, cables, and thorough creasing of all sheaves in order that they may have free movement for all cables.
- ☐ 8. Be sure the drawworks skid is tied down to the pump or caterpillar that may be standing by, in order to prevent any over-balancing.
- ☐ 9. Check to see deadline is tied down secure with enough clamps.
- ☐ 10. There must be a complete visual check of the derrick before it goes up to be sure there are no loose bolts, bars or any drift pins that are left without a safety bolt in them to prevent working loose.
- ☐ 11. Keep tong counterbalances tied in the down section.
- ☐ 12. Always have two men at the brake, should the man at the brake need help he can be assisted by the other. **Have other crew members at a safe distance from the rig floor and the derrick should it collapse.**
- ☐ 13. **Never at any time should there be anyone on the "A" legs while derrick is being hoisted. Always wait till the derrick has come to a complete rest before going up the "A" legs to put the stay bolts in.**
- ☐ 14. Be sure and use a snubline on the derrick when letting the derrick into the final position. If allowed to fall into position, this sometimes causes a great deal of vibration in the derrick and great strain put on the pins at the base of the derrick.
- ☐ 15. Be sure that the traveling blocks are used when moving the derrick as they will prevent any movement of the "A" legs that could possibly break the "U" bolts that are on the front leg of the "A" legs. Should these "U" bolts be broken and the "A" legs raised, there would be nothing to hold them from folding backwards when they were raised before the "A" leg pin was put into position.
- ☐ 16. In lowering derrick the same procedures are to be used wherever applicable and the same safety precautions taken with regard to men and equipment.

LEE C. MOORE

TRAILER MOUNTED MASTS

. . . transported with lines strung

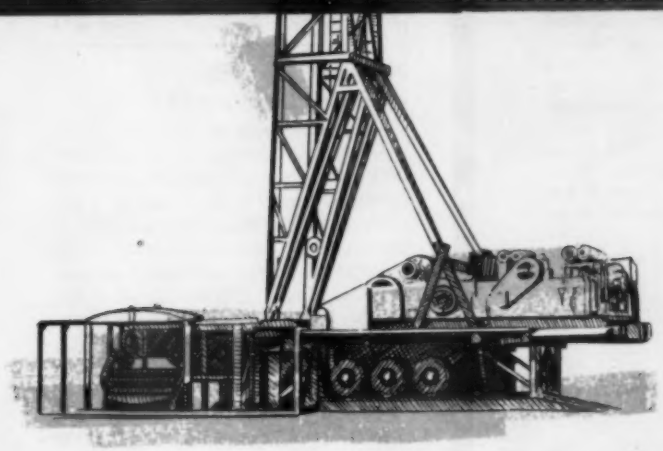
A Lee C. Moore trailer mounted mast is designed so that complete mast and accessories can be transported with blocks strung . . . another reason why Lee C. Moore masts save valuable time in rigging up and tearing down operations.

SINGLE TRAILER MOUNTED MASTS

86 ft. 94 ft. 97 ft. 97 ft. Heavy duty 100 ft. 126 ft. Export model

DUAL TRAILER MOUNTED MASTS

97 ft. 100 ft. 126 ft. 126 ft. Export model



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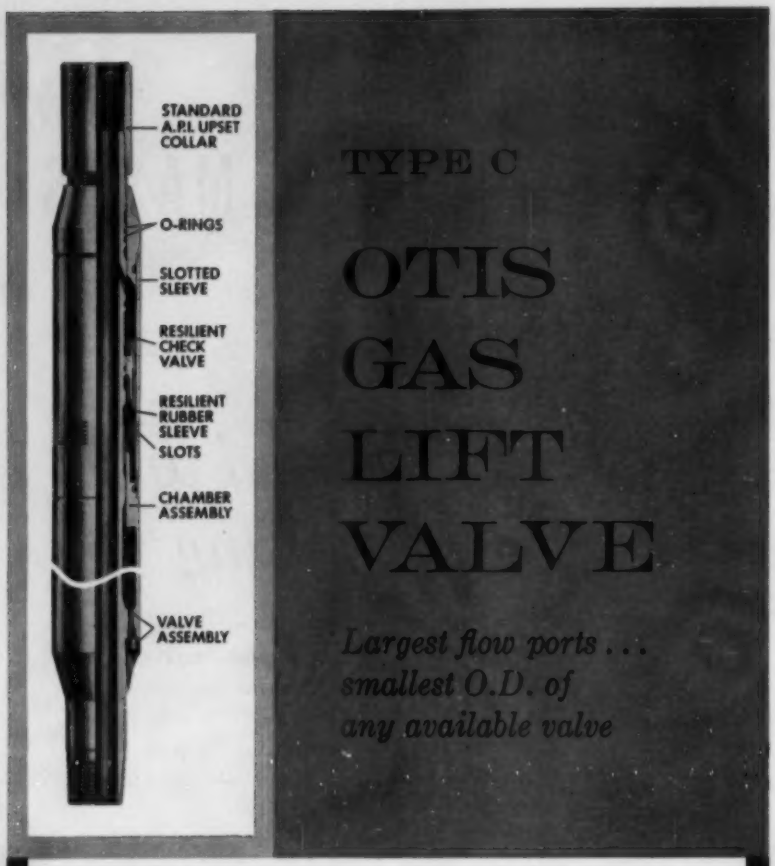

The operating principle of the Type C Otis Gas Lift Valve is so completely different from conventional gas lift equipment that it makes available certain production practices that heretofore have not been possible for wells on gas lift.

Remarkably simple in design and construction, Type C valves can be used for continuous or intermittent flow, they can be used in dual completions, they are adaptable to permanently-completed wells, they can be adapted for casing flow, and certain sizes can be installed without pulling tubing.

A resilient rubber sleeve is the only moving part, and extremely small opening and closing differentials are possible, even with sand-laden fluids. The valve is built *around* a full-opening mandrel (rather than alongside the tubing) which affords greater strength than the tubing itself. The check seals positively and does not require velocity to close. When used in an intermittent operation, a minimum amount of gas is required to lift the load of fluid, regardless of surface choke settings or long flow lines.

The Type C Otis Gas Lift Valve has so many significant advantages that we believe it has advanced gas lift technology by at least ten years. Ask an Otis man why.

OTIS

OTIS PRESSURE CONTROL, INC.

Gas Lift Division: 2402 Broad Street, Houston

Branches Throughout the Oil Country

Haste Makes Waste

Finally, the last point to remember is that in rig moving we must depend on human action, human control, and human nature. We can race a motor to a rate of speed much greater than normal, but a human being has only a limited speed. If that speed is increased beyond its allowance, the individual loses all coordination and becomes in himself a hazard. Speed in rig moving is only as fast as the slowest player on the team. Use this measure to gage your speed for efficiency and safety.

The Author

J. L. Muir has served as safety director of General Petroleums of Canada, Ltd., since 1949. He has been a member of the Safety Committee of the American Association of Oilwell Drilling Contractors since 1950, and is a member of the Safety Committee of the Canadian Association of Oilwell Drilling Contractors, acting as chairman for 1956. He is also a member of the Safety Committee of the Canadian Petroleums Association.

Muir was a member of the Royal Flying Corps in World War I, later joining the Royal Canadian Mounted Police in 1922. He served with the group until 1949, retiring with rank of full sergeant, acting as non-commissioned officer in charge of highway patrols in the province of Alberta.

Acknowledgment

This paper was first presented May 12, 1956, at the Rocky Mountain Regional Safety Clinic, sponsored by the Casper Chapter of the American Association of Oilwell Drilling Contractors.

* * *

Phillips Core Drills Find Rich Uranium Ore

Phillips Petroleum Company's exploration has discovered a new 1,500,000 ton high-grade uranium ore body in New Mexico in the heart of a district said to contain three-quarters of known U. S. uranium reserves, K. S. Adams, chairman, and Paul Endacott, president, have announced. The discovery resulted from intensive core drilling on a 1280-acre mining lease in the Ambrosia Lake area near Grants, New Mexico. The company is acquiring full working interest in the lease by purchasing the remaining one-quarter interest previously held by Holly Minerals, Inc.

Further drilling by Phillips continues on the unexplored portions of the lease. Engineering studies of the ore body are underway.

In competitive contract drilling . . .

Use of a BIDSHEET In Making Drilling Bids

. . . will pay off if all costs are judiciously and systematically accounted for in a manner that includes a realistic profit. Here's how it's done

W. K. Powell
President, Beard Drilling Company
Duncan, Oklahoma

MAKING a realistic drilling bid today is more of a "science" than an "art" as it has been referred to by some. There may be an "art" in negotiating a contract where the imponderables and general cussedness of human nature enter into the question. The term "science" implies the ability to produce facts, figures and calculations that can be verified.

In the preparation of a bid, all information pertaining to the well to be drilled should be sought from the operator's engineering and geological departments, as well as your own engineering and accounting groups. Figures and information so obtained should then be analyzed and evaluated carefully with respect to your own operating costs for each operation involved. The sum of the costs, plus that item you are in business to make **"your profit,"** should equal your price.

The field price. In contract drilling, there is a "field price", which is the price more or less set by previous con-

AADOC Bid Specifications and Estimate Form, developed after considerable study and based on wide experience, is applicable on practically all cases and will provide a more realistic bid.

BID SPECIFICATIONS

OWNER: WELL: No.:

RIG No.: DATE START:

Location Time:	Estimated	Actual
Rig Up	Days	Days
Drlg. Contract Days	Days	Days
W.O.C., Completion and Free Time	Days	Days
Tear Down	Days	Days
TOTAL	Days	Days

Contract Footage Depth: Maximum Depth: Formation:

Deviation From Vertical:

CASING PROGRAM:	Size Inches	Weight Lbs./Ft.	Hole Size Inches	Approx. Depth — Ft.	Cement Time Allowed — Hrs.
Conductor Pipe					
Surface					
Protection String					
Oil String					
Liner					
Tubing					

MUD CONTROL PROGRAM:

Depth Interval From	To	Type Mud	Weight	Viscosity	Water Loss

Loss of Circulation Clause:
Weight Clause:
Other Protective Clauses:

INSURANCE LIMITS:
PL: PD:
Other Insurance Required:

ITEMS TO BE FURNISHED BY:	OWNER	CONTRACTOR
Mud		
Roads and Clearing		
Rig Fuel		
Rig Fuel Lines		
Rig Heating Fuel		
Water		
Water Lines		
Transportation of Contractor's Property:		
Move In		
Move Out		
Operational Transportation		
Materials for "Boxing In" Rig and Derrick		
Pits and Cellar		
Core Bits		
Core Barrel		
Bits, Reamers and Stabilizers		
Drilling In Equipment		
Other:		

BID SHEET

Owner: Well Name: No. Date:

Account No.	DIRECT EXPENSE	Per Day	Well Estimate	Actual
90-11-1	All Labor Except Supervision			
90-11-12	Supervision Incl. Trans. and Expense			
90-11-2	Supplies			
90-11-3	Maintenance and Repairs			
	Total fixed DIRECT EXPENSE per day			
	times estimated days			
	OTHER DIRECT EXPENSE			
90-11-41	Bits and Reamers			
90-11-42	Move In & Out — Rigging Up & Down			
90-11-363	Other Transportation			
90-11-511	Pits, Cellar and Dirt Work			
90-11-512	Derrick			
90-11-513	Lumber			
90-11-514	Other Preparation			
90-11-52	Rig Fuel and Lines			
90-11-524	Heating Fuel			
90-11-53	Water and Lines			
90-11-54	Mud and Chemicals			
90-11-57	Special Taxes			
90-11-58	Special Services to be Furnished by Contractor			
90-11-59	Special Material to be Furnished by Contractor			
	TOTAL OTHER DIRECT EXPENSE			
	INDIRECT EXPENSE			
90-11-81	Rig Depreciation			
90-11-82	Drill Pipe Depreciation			
90-11-822	Drill Collar Depreciation			
90-11-9	Overhead Expense			
	TOTAL INDIRECT EXPENSE			
	TOTAL ALL EXPENSE			
	PROFIT			
	ESTIMATED COST PLUS PROFIT FROM CONTRACT DRILLING			
	ESTIMATED COST PLUS PROFIT $ DIVIDED BY FEET CONTRACT DEPTH			PRICE PER FOOT
	DAY WORK			
	Fixed Direct Expense Per Day			
	Other Applicable Expense (Fuel, Water, Etc.)			
90-11-81	Rig Depreciation per Day			
90-11-9	Overhead Expense per Day			
	PROFIT			
90-1	DAY WORK RATE WITHOUT DRILL PIPE			
90-11-82	Drill Pipe Depreciation plus			
90-11-822	Drill Collar Depreciation			
90-1	DAY WORK RATE WITH DRILL PIPE			
	Standby Time with Crews			
	Standby Time Without Crews			

Calculated By: Date: Approved By: Date:

Lone Star Steel was built to make API pipe for the oil and gas industries . . . and is now building another open hearth furnace and even greater pipe mill facilities in line with demand.

Our long-time friend, Joe Roughneck . . . heart of the industry . . . needs more and more pipe. Lone Star is preparing to deliver more API casing, tubing and line pipe now . . . and in the years to come.

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tracts in the field. Should your bid be lower than the field price for the well, it should be checked for two possibilities; first, to see if there are any inaccuracies in the calculations; and second, to see if your engineering department has calculated that by using a better drilling assembly or a better hydraulic system (i. e., a type of drilling fluid that allows a more rapid rate of penetration, a better selection of bits and jets and pumps), by which the drilling time may be reduced. It is a much more pleasant situation on reviewing your calculations to find the second condition is the case.

The bid sheet. In order to improve the accuracy of calculating the cost of drilling to the contractor, a bid and specification form of some kind should be used. My company uses one developed over the years of our operations which has proved invaluable in preparing bids. Two or three years ago, the Acccunting Committee of the American Association of Oilwell Drilling Contractors, after considerable study, issued a bid and specification form similar to the one we use. The AAODC form shown in Fig. 1 was developed from material given in the "Manual of Accounting Practices and Procedures for the Oil Well Drilling Contractor."

The AAODC Form primarily consists of two pages: the bid specifications and the bid sheet proper. On the "Bid Specification" page are outlined all of the pertinent material given in the operators request for a bid. Well location, footage depth, deviation, casing program, protective clauses, insurance limits and items to be furnished by the operator and/or the contractor are outlined. This serves as a check on the request for bids and eliminates the guesswork in trying to figure out just what the operator had in mind in his request. A few minutes conversation on the phone can usually clear up any ambiquity that exists.

Bid specifications should define the responsibility for each operation in drilling and completing the well. Answers should be provided such questions as: who furnishes the drilling fluid, water, core barrels and bits, and so on; where do day-work charges begin in lost circulation areas and zones, the use of mud over 12 lb per gallon, chert and pyrite formations; and what constitutes acceptance of the well by the operator . . . is it when the contractor is told to run casing, or after the casing has been run, cemented and drilled in?

Mud program. The mud program specified by the operator should be examined closely by the contractor. In most drilling areas, the rate of penetra-

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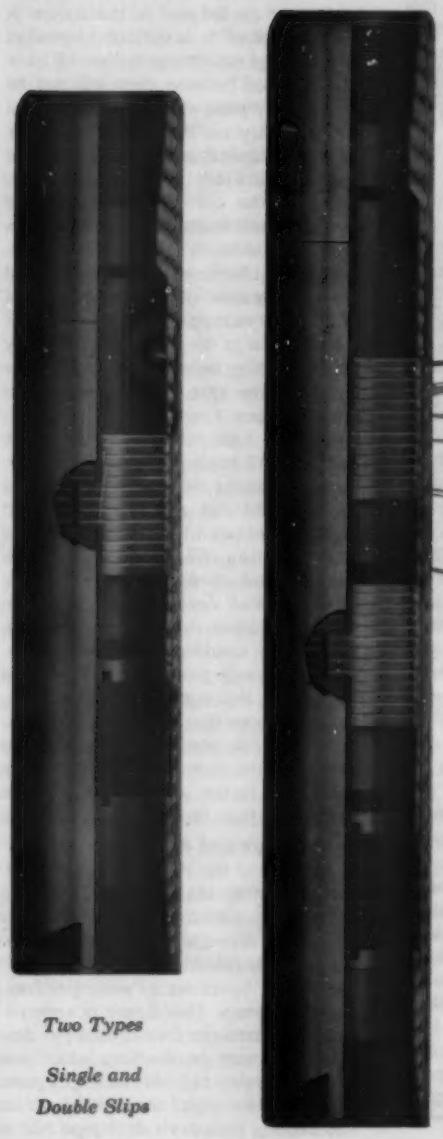

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Single and Double Slips

The ideal tool to repair damaged or split casing in the well because of its ease of operation and efficiency.

Here's how —

- Cut casing below defective area and remove from well.
- Replace defective portion and attach Casing Bowl to the bottom of the replacement string.
- Run casing back until casing standing in the well "shoulders" inside the bowl.
- Pull up to set slips and expand packing—and the job's done.
- Segmented lead packing assures a pressure-tight, permanent seal.

With this tool the cement job around the casing is not disturbed —nor is the inside diameter of the casing string reduced. Tools that pass through the casing will also pass through the Bowl.

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tion is in inverse ratio to the viscosity of the mud. That is, the lower the viscosity, the faster the rate of penetration. Water, with a viscosity of 1.0 centipose, approximates the ideal drilling fluid. However, recent studies on the use of gas, air and aerated muds indicate the possibility of improvement over the use of water. In all drilling on a footage basis contract, the contractor is, in a sense, drilling against time for his profit. It behooves him to work with the operators geological staff and engineers to obtain a mud program that will allow him to make the maximum speed in getting the hole down and still not endanger himself with cave-ins or blow-outs, yet give the operator a clean, operable well.

Insurance. Insurance limits are often a source of needless contention between operators and contractors. It should be defined in the request for bids or in request to negotiate, just what insurance the contractor is expected to carry other than fire and wind storm damage to the rig and workmens compensation. Public liability and property damage limits should be defined.

In some areas the contractor is required to carry a special insurance against blowouts that do not blow out or can be controlled by surface equipment. In this case, portable water sands just below the surface are damaged by pressure which causes them to flow abnormally or become contaminated with salt, mud and oil and/or gas. While such insurance clauses in the contract define the responsibility, they most certainly have to be figured in the cost of drilling that particular well.

Study contract carefully. As to whom shall furnish such items as mud, water, fuel and clearing roads, are generally well defined in contracts of most major companies and the AAODC Standard Rotary Rig Contract. However, there are numerous instances that indicate specifications in the request are loosely drawn or the contractor failed to study them carefully before submitting the bid. Blow-out preventers often are not specified in contracts with small operating firms. Failure to specify them in some cases has thrown responsibility of the blowout on their shoulders, but it fails to compensate the contractor for the loss of his rig. And also, the contractor is burdened with higher public liability and property damage insurance because of his failure to supply adequate blow-out prevention equipment.

Cost tabulation. On the second page of the bid and estimate form, cost of items set forth in the specifications are tabulated and the total cost of drilling is calculated. There are five columns. The first column is for account numbers which are the same as account numbers on the "Well Cost Extension Chart" of the Accounting Manual. The second column is for the description of the account. The third column is for the calculated cost per day of each item of expense, and the fourth column is for the "Well Estimate" which is calculated by multiplying the per day expense by the number of days estimated to drill. The fifth column is for actual costs determined after the well has been completed and filled out for references on subsequent bids.

The bid sheet is divided horizontally into sections with respect to the type of "Expense". These are headed on this form, "Fixed Direct Expense", "Other Direct Expense", "Indirect Expense" and "Profit." Total of the "Expenses" plus "Profit" divided by the number of feet to contract depth gives the "Price Per Foot."

"Indirect Expense" is perhaps the most controversial group of items noted on this sheet. "Rig Depreciation" and methods for determining it have resulted in no end of disputes between contractors and their accountants and between contractors themselves. A description of the method of charging rig depreciation is given in the explanation of the "Well Cost Extension Chart" of the Accounting Manual. It states that: "Rig depreciation is charged to the well on a basis of rig operating days times the depreciation factor. The depreciation factor for the rig is obtained by dividing the rig value by its estimated actual working life in terms of days or by any of the other accepted methods. If the contractor is unable to adopt this method of rig depreciation, or feels no desire to use it, for reason of other advantage, the advantages of direct and prompt application of this factor may be obtained by using a rig depreciation factor in this manner; crediting an account entitled Rig Depreciation Reserve Estimate. At the end of the fiscal period, the Estimate Account is cleared into the Regular Reserve Account and the difference in the amounts shown directly on the Profit and Loss statement with the proper explanations. This method will make the Rig Depreciation an **integral part of and an unforgettable item in the cost of drilling a well."**

Although the above may be in "accountant's language," its meaning will be clear to anyone who is qualified to look over his own balance sheet.

Rig Depreciation. A figure widely used for the life of a rig is 1500 working days. Using this figure and dividing it into the total cost of the rig is approximately the per day depreciation of the rig. In other words, by the end of 1500 days of work with the rig, sufficent money should be in the depreciation account to replace the rig. All too often in these days of rough competitive bidding, the depreciation factor is ignored or the money so set aside goes to pay for other expenses. Then comes the day when a new rig is needed to stay in business and the contractor has to stand, hat in hand, before the supply company credit manager. Excuses that seemed so valid when the depreciation account was raided appear to be rather thin now.

Rig obsolescence. An intangible item that is bound to appear with greater frequency on ledgers in the future is "obsolescence." It is difficult to predict how fast rigs now in operation will have to be retired because they will not be able to keep pace with new designs that are presently on the drawing boards. This will depend on a number of economic factors involved, such as the rate at which the old rigs can be traded in with sound economic balance within the supply industry; expense of re-tooling to manufacture these new rigs and the amortization of this cost; the cost of literally scrapping stocks of parts for rigs now in the field and the ability of the drilling industry to absorb new rigs from the base of its present economic position.

On this basis, the impact of these changes will begin to be felt in the industry in about two or three years as the demand for more wells, drilled faster, increases to the point that rigs now operating will not keep pace with the demand. Some rather shocking pressures may develop because of this demand within the drilling industry. When this condition does occur, obsolescence will pass depreciation as a reason for retiring a rig from service. Intangible as the figure for obsolescence is, each contractor is advised to peer into the future, estimate the obsolescence factor, and put this figure in every bid that he prepares currently.

Drill pipe and drill collar depreciation are also the two figures in "Indirect Expense" that often are hard to estimate. For many years, a factor for drill pipe depreciation has been used that is fairly reliable in most areas. This factor is a figure on a "price per foot, per day" basis. This figure is approximately 2 cents per foot drilled per day. This cost may be startling when you total up your bid. However, figures given in "Iron Age" magazine indicate the drilling industry's drill pipe bill in 1952 was about 32 cents per foot of hole drilled. Several contractors believe this figure was too low.

There are areas in which the drill pipe is an "expense item." That is, it can be

charged off or depreciated in one year. These areas are often a pit-fall for the unwary contractor where the operator fails to warn him of this condition, should the operator be aware of it. A case in point is one that occurred in the southern part of the Permian Basin where a contractor, who not aware of the corrosive conditions encountered there, bid $2.00 per ft under the field price on a contract. He did not know until after he had received the contract that a ten thousand foot string of pipe would not last over four wells and that grade E pipe would deteriorate so rapidly that joints would have to be layed down before the first well was completed. He had based his bid on nominal pipe wear. Needless to say, the contract was returned to the operator.

Drill collar depreciation is another item that must be based on field experience. In the hard rock drilling areas of West Texas and the Rocky Mountains, drill collars wear rapidly, while in the Mid-Continent and Gulf Coast areas, the rate of wear is almost a third to one-fourth of the West Texas rate. With the gradual increase of steel prices, don't overlook these two items on your bid sheet.

Overhead expense. The last item in this group, Overhead Expense, is often the most miscalculated one. It is the sum of General Overhead Expense and Administration Expenses. These two items continue regardless as to whether the rig is stacked or is working. On a per-day-per-well estimate, the estimate can be calculated on the basis of possible number of wells the rig can drill in one year, down time for moving in and out and rigging up and down included. After a contractor has been in business for two or three years, overhead costs will have become established and may be estimated with considerable accuracy. This expense covers such items as the cost of preparing reports, calculating bids, records and accounting, including all work incidental to an office, operating and financing a business.

Administration Expense certainly deserves a word here. This covers the costs of management, your salary as the boss, your expenses and those allowed the management staff and their salaries. Quite often, some contractors, operating one or two rigs, do not figure a salary for himself in the Overhead Expense, taking the profit made on the well as his salary. Reasons for not taking the profit as your salary may be questioned, but if any one who does this would discuss it with a certified public accountant, will become aware of the error of his ways.

Realistic bids will help. A number of Drilling Contractors say that drilling prices are so low that they simply were not making any money. They were going out of business for one of two reasons: (1) they were broke, and (2) they were not making a legitimate profit on their investment and were quitting before the hazards of the business caught up with them.

The footage price in the industry today reflects condition of the industry's economy. This condition has been brought about by the lack of adequate accounting procedures and poorly calculated bids. To get out of this slough the industry will have to perform what is known as "operation bootstrap". At the risk of being facetious, I suggest the industry might organize "Drilling Contractors Anonymous," similar to the famous A. A. society, to help those contractors who are addicted with the desire to always turn in the lowest bid regardless of the consequences to himself and the contracting industry.

Without accurate accounting procedures developing within the industry so that bids can be made that will include a fair profit and a return on investments, the average contractor will find himself in the same position as the newsboy who bought his papers for two cents and sold them for two cents. He did get a chance to holler. ★ ★ ★

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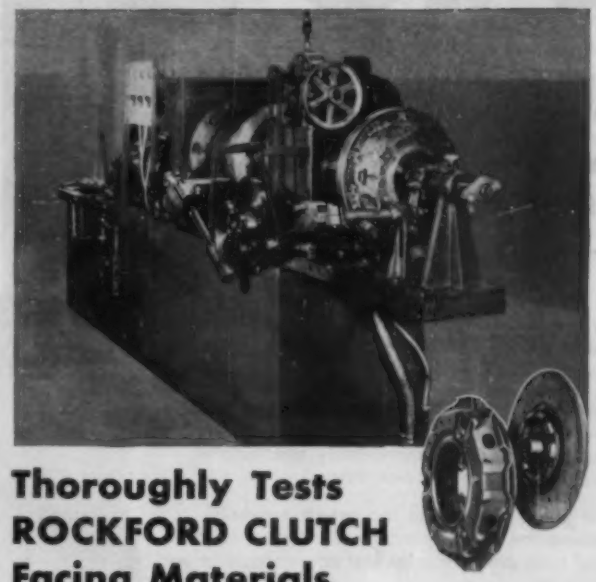

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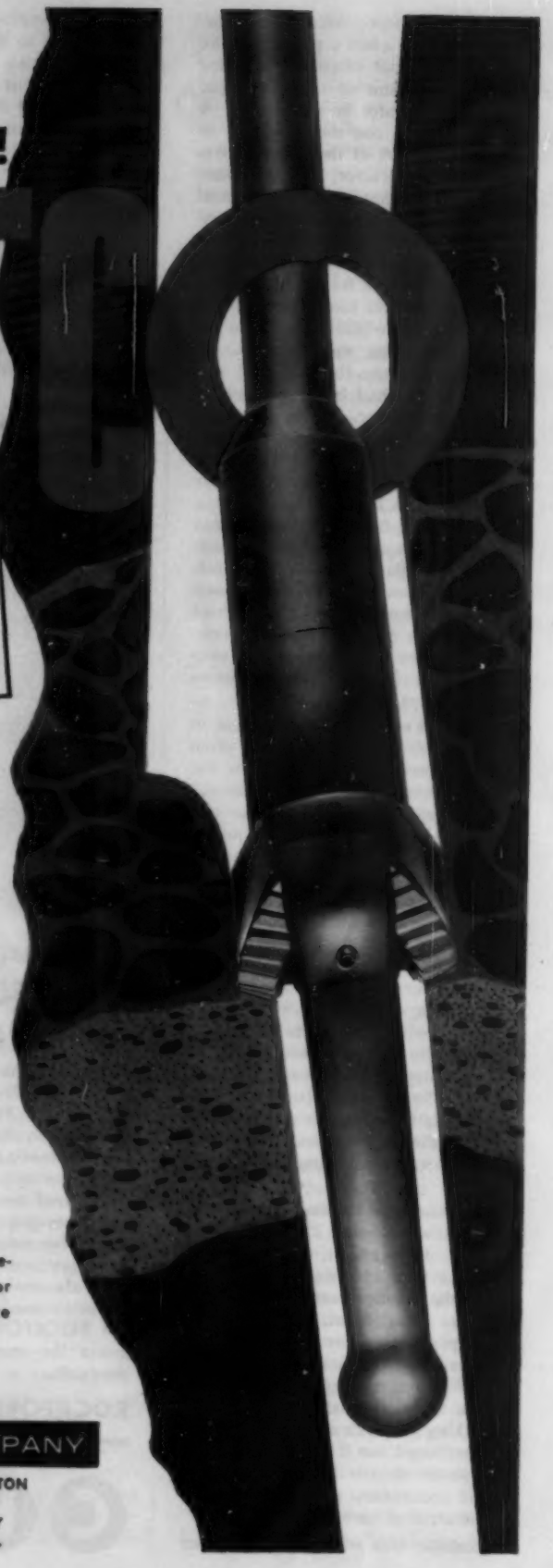

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How to calculate fluid . . .

Friction Losses During Well Treatments

A new approach to determine pump requirements for high injection rate fracturing. Examples are presented

Robert Wade Brown,
The Western Company, Midland, Texas

THE practice of high injection rate fracturing treatments has initiated a concern about the flow characteristics of fracturing fluids. Usually, an operator will know the injection rate he would like to have. In order to know the pump horsepower required to develop this injection rate, it is necessary to know the pressures that will be encountered. Statistical data are available to provide an estimate of the bottom-hole pressure to be expected. To this pressure must be added the pressure required to move frac fluid down the casing (or tubing) from the surface to the bottom of the well. There are three general types of fracturing fluids now in use: Refined oils, gels, and emulsions (acid-kerosene).

These three types of fluids exhibit different flow characteristics. In other words, considerably more pressure will be required to move frac oils than will be required to move gels. More horsepower will be required to perform a refined oil treatment than will be required to perform a gel treatment at the same injection rate.

To further complicate the problem, none of these fracturing fluids are "true fluids" in that none of them exhibit newtonian properties. Pressures required to move them cannot be calculated with reliability using the classic flow formulae or using engineering handbook data.

A study has been undertaken to develop means for determining the pressures needed to move various fracturing fluids at various rates. This study has been conducted under field conditions. Formulae and procedures for determining pressure loss due to friction have been developed using data

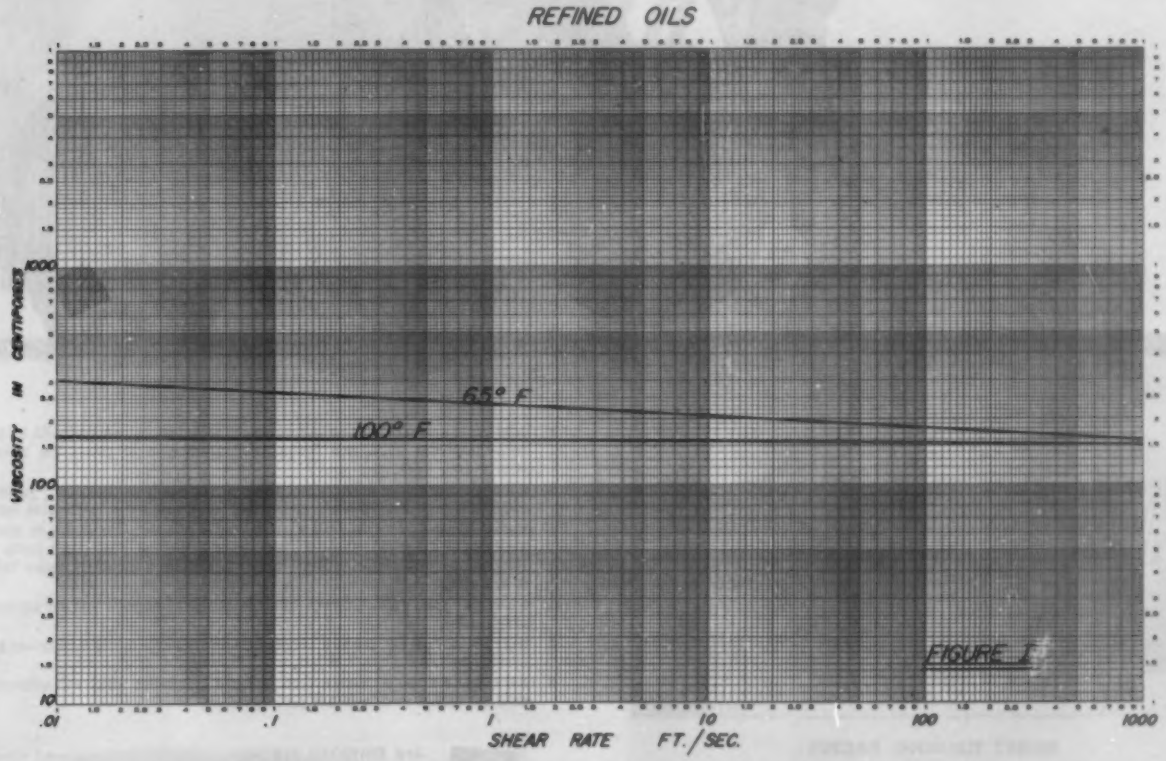

FIG. 1. **Viscosity variation of refined oils** with variable rates of shear at two different temperatures.

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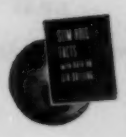

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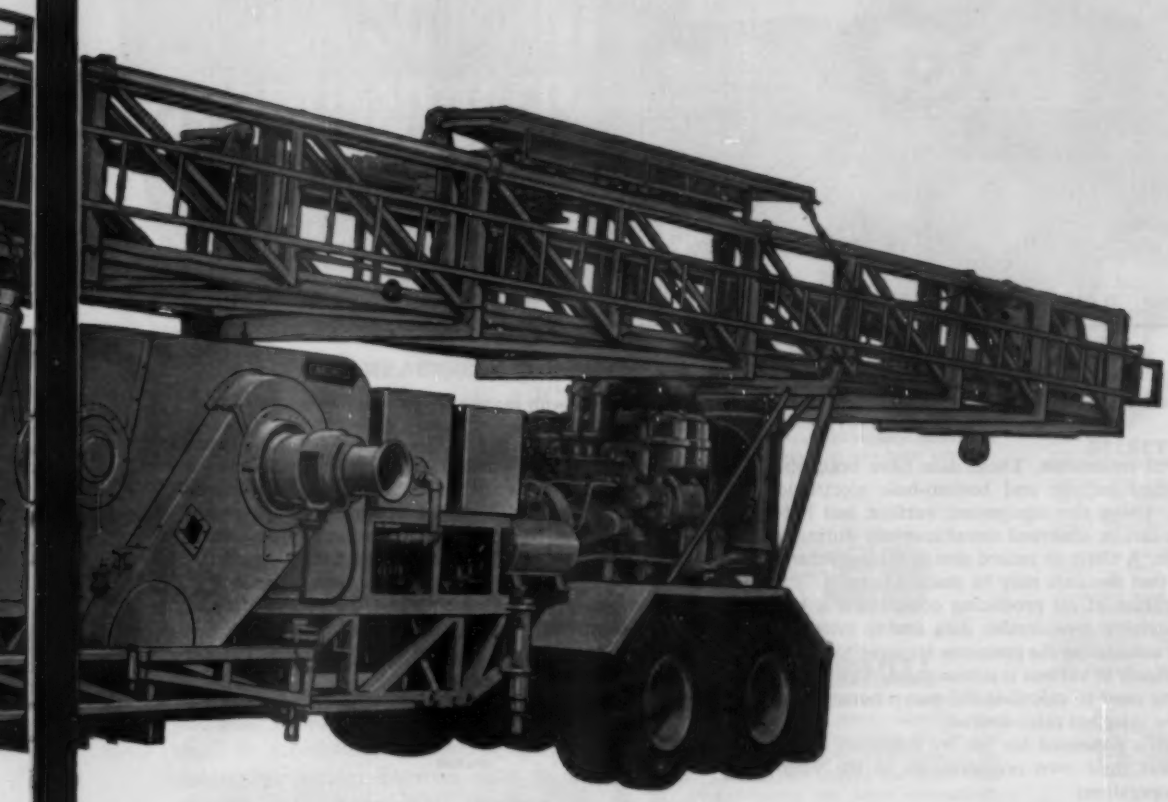

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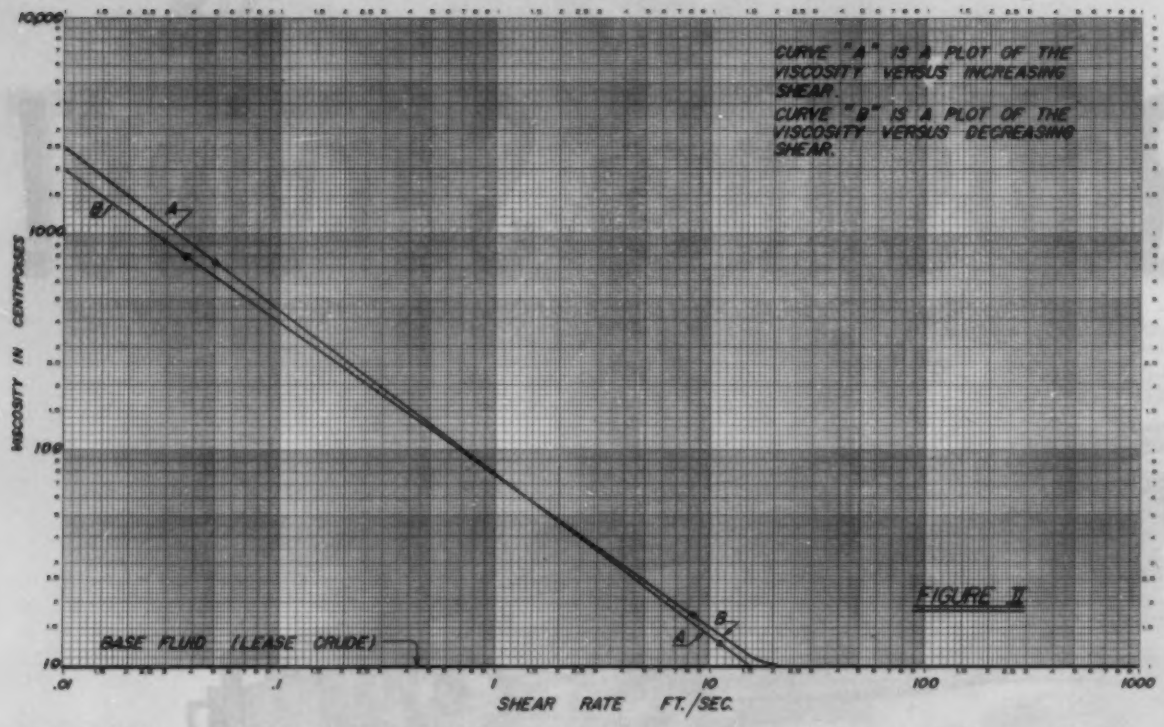

FIG. 2. **Variation of viscosity of gels** with variation in shear rate as compared with lease crude shown as the base line.

obtained during well treatments. These data have been obtained with combined surface and bottom-hole electronic pressure recorders. Using this equipment, surface and bottom-hole pressures can be observed simultaneously during a fracturing operation. A chart or record also is made of these pressures in order that the data may be studied later.

With the cooperation of oil producing companies, it has been possible to assemble considerable data and to integrate it into a method for calculating the pressures required to pump various fracturing fluids at various injection rates. This information is now being used to calculate the pump horsepower requirements for the injection rates desired.

This information is presented for use by engineers to investigate and predict their own requirements in the planning of fracturing operations.

Theory

The first factors considered in the calculation of pressure loss (dP) were the rheological properties of fluids utilized in hydraulic fracturing. First was the variation of viscosity with a variable rate of shear. Figs. 1, 2, and 3 exemplify the results obtained for each of the three general classifications of fracturing fluids: (1) refined oils, (2) gels, and (3) emulsions. In view of this information the following equation was derived:

$$u_{act} = V^m u_{meas}$$

But, since m is either zero or has a negative value for all the fluids under consideration

$$u_{act} = \frac{u_{meas}}{V^m} \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Where m is the absolute value of the slope of viscosity vs shear rate curve (for the gels analysed and for newtonian fluids, m has a value of zero; for refined oils below 100F and for emulsions, m has a negative value), u_{act} is the apparent viscosity at the shear designated, V is the shear, and u_{meas} is the viscosity measured at a shear rate of 1 ft per sec and at the desired temperature. (The shear induced by the viscosimeter and the shear encountered in the conduit are considered equivalent.) The "desired" temperature is the temperature of the treating fluid at down-hole conditions. This temperature is based on surface temperature, bottom-hole temperature, and injection rate. At injection rates above approximately 20 bbl per minute through 5½-in. casing and in wells less than about 5000 ft deep, temperature of the fluid in the conduit is effectively that of surface conditions.

During that part of the treatment where sand is employed,

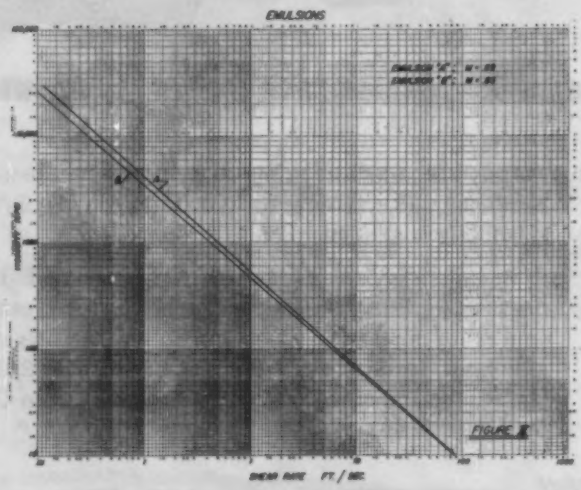

FIG. 3. **Viscosity variations of two emulsions** with different shear rates are shown above.

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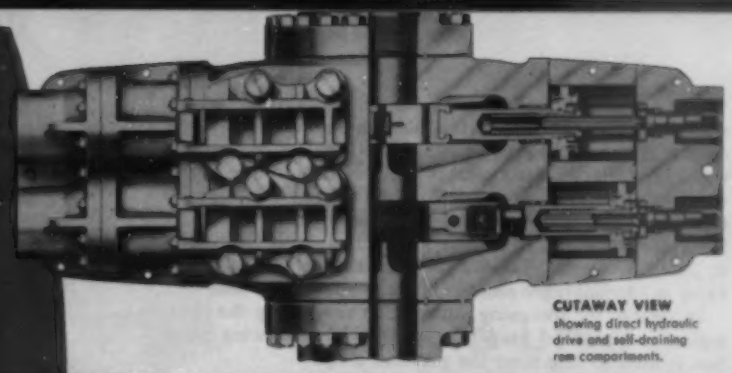
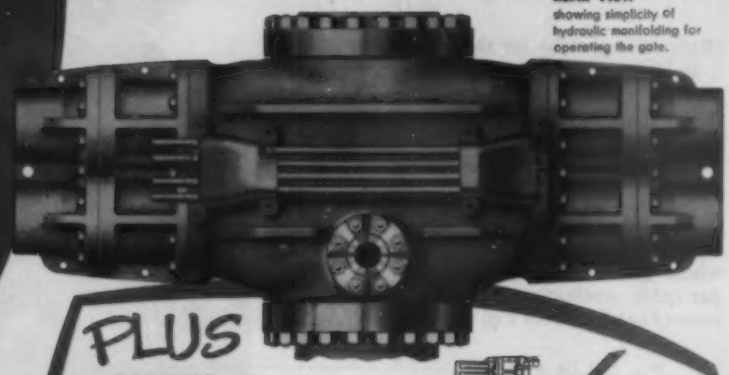


CUTAWAY VIEW
showing direct hydraulic drive and self-draining ram compartments.



REAR VIEW
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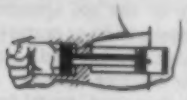

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the total fractional volume of the sand (C_o) should be considered. This correction follows Eiler's equation for C_o values of over 0.1 and Einstein's equation for C_o values of less than 0.1. Fig. 4 gives the n_r value which corresponds to the respective total fractional volume of sand (C_o). The value n_r is the ratio of the viscosity of the sand-laden fluid to that of the homogeneous fluid. This value (n_r) is then multiplied times u_{act} to correct the viscosity for the sand content. (The n_r value is 1 for all homogeneous fluids.)

In view of the foregoing information concerning the rheological and physical properties of fluids the following equation is used to determine the pressure drop:

$$dP = \frac{32\, f\, Q^2\, L\, p}{\pi^2\, D^5} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

(Refer to Appendix for the derivation.)

where $f = 0.0035 + 0.264 \left(\frac{1}{N_{Re}}\right)^{0.42}$

for turbulent flow and

$f = 16/N_{Re}$ for laminar flow.

Converting Equation 2 into convenient units we have:

$$dP = \frac{95.176\, f\, Q^2\, L\, p}{\pi^2\, D^5} \quad . \quad . \quad . \quad . \quad . \quad (3)$$

where Q is in barrels per minute, L is in feet, p is in grams per cubic centimeter, D is in inches and dP is in psi. The factor f is taken from Fig. 6 where

$$N_{Re} = 1.04 \times 10^5 \frac{(p\,(4Q)^{1+m})}{(D^{1+2m}\quad n_r\quad u_{meas}\quad \pi^{1+m})} \quad . \quad (4)$$

Here $|m| < 1$, u_{meas} is in centipoises, n_r is dimensionless, and other units are identical with those in Equation 3.

Refined Oils

Refined oils at temperatures above approximately 100F behave as newtonian fluids, and have a slope (m) of zero. Below approximately 100F, slope of the refined oils is less than zero and m has a negative value.

Gels

For gels, gelled water and gelled oil specifically, viscosity decreases rapidly with increasing shear until the gel has effectively the same viscosity as the base fluid, and in both cases, the base fluids exhibit newtonian properties. The point where viscosity of the gel approximates the viscosity of the base fluid (lease crude or water) occurs at such a shear that during practically all well treatments, they are synonomous. This low treating viscosity affords a low friction loss, much lower in fact than would be observed with either refined oils or emulsions under identical conditions.

A point of interest concerning these gels is the "hysterises loop" that the viscosity vs decreasing shear rate portrays. (Fig. 2.) The viscosity increases with decreasing shear, enhancing both the sand-carrying capacity and the low fluid loss of the fluid. This means that during treatments at high shear rates, the friction loss is relatively small. As fluid enters the fracture, shear rate decreases, viscosity increases, and sand is carried further back into the formation with less fluid loss.

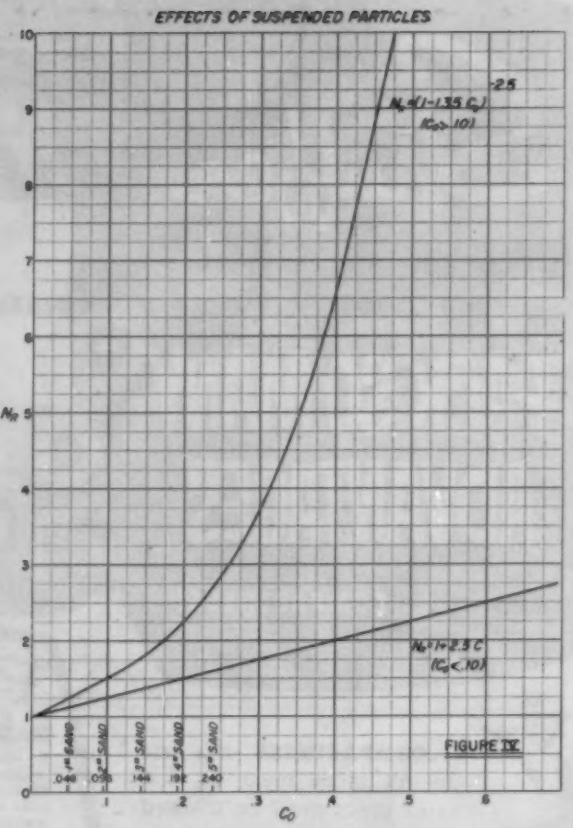


FIG. 4. **Fractional volume of sand** (C_o) corresponding to the ratio (n_r) of viscosity of the sand-laden fluid to the homogeneous fluid.

Emulsions

Emulsions studied produced slightly different results. Slope of viscosity vs shear rate curve does not become zero in the shear region studied; hence, viscosity of the emulsion cannot be considered equivalent to the viscosity of the base fluid (Fig. 3.) A value of these slopes is determined for each emulsion and applied to Equation 1. This value of m is subject to variation between different emulsions and in some cases it may vary with the time of agitation on a specific emulsion.

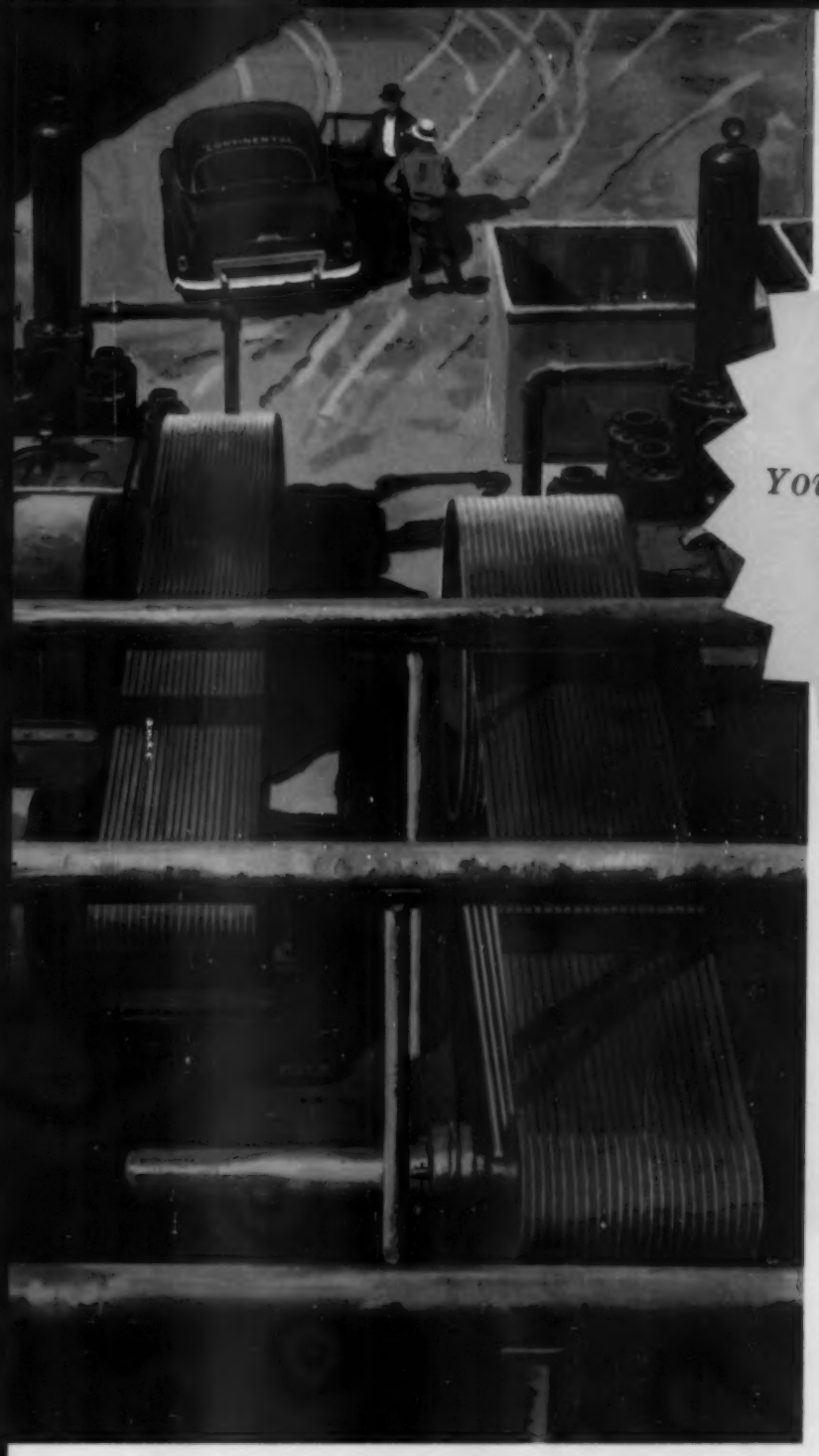
TABLE 1.

p(gm/cc)	u(cp)	D(in.)	Inj. Rate(B/M)	L(ft.)	dP calc. (psi)	dP obs. (psi)	m	% Error
			GELLED OIL					
0.847	10.0	6.25	47.0	4000	382	332	0	+15*
1.0075	12.5	6.25	46.2	4000	455	436	0	+4
0.847	10.0	6.25	36.2	4050	260	263	0	−1
1.0075	12.5	6.25	36.2	4050	300	360	0	−16*
1.0075	12.5	4.00	25.0	3925	1190	1120	0	+7
			GELLED WATER					
0.999	1.0	5.00	42.0	2520	562	554	0	+1.5
1.11	1.2	5.00	42.7	2520	655	715	0	−8
			REFINED OIL					
1.0	150.0	3.00	10.3	3950	1970	1960	0	+0.5
			EMULSIONS					
1.15	625.0	5.01	26.0	5525	1060	1030	0.85	+6

*Instantaneous injection rates recorded indicated a wide variation from the average during the treatment.

The Author

Robert Wade Brown is a research chemist for The Western Company of Midland, Texas, in their research laboratories. He received his BS degree in chemistry and mathematics and a MS degree in chemistry from North Texas State College in Denton, Texas. At NTSC he was a charter member of the Beta Eta Chapter of Alpha Chi Sigma fraternity and an active member of several other fraternities and clubs. He was also a student instructor and graduate tutor in the NTSC chemistry department. Prior to joining the Western Company, he was employed in the chemical laboratory at Temco Aircraft Corporation at Grand Prarie, Texas, near Dallas.



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Calculated and Observed dP Values

A comparison of actual dP values taken from bottom hole pressure data (obtained from a surface recording pressure bomb that was situated in the well during the fracturing treatment) to values calculated from Equation 3 are presented in Table I.

EXAMPLES OF CALCULATIONS

A. Gels: On this job, the injection rate was designed to be 35 bbl per min., casing was 5½ in. (J-55-14 lb), well depth was 4000 ft, the gel was made from lease crude of 10 cp viscosity, specific gravity was measured at 0.847 gms per cc. Two pounds of sand per gallon was desired.

$p = 0.847$ without sand

$p = 1.008$ with 2 lb sand per gal from Fig. 5

$c_o = 0.0958$ for 2 lb sand per gal

$n_r = 1.25$ from Fig. 4

$u_{act} = 10$ cp without sand

$(u_{act})(n_r) = 12.5$ cp

$m = 0$

$$N_{Re} = 1.3258 \times 10^5 \frac{(1.008)(35)}{(5.01)(1.25)(10)} = 7.41 \times 10^4$$

$f = 0.00565$ from Fig. 6

$$dP = \frac{(29.314)(0.00565)(35)^2(4000)(1.008)2^5}{\pi^2 (5.01)^5}$$

$= 845$ psi

B. Refined Oil: For this consideration the same conditions prevail as with the gel except the specific gravity was measured at 0.91 gms per cc, and the viscosity was measured at 130 cp. The fluid indicated newtonian properties. (The treating temperature of the fluid was 102F)

$p = 0.91$ without sand

$p = 1.062$ with 2 lb of sand per gal from Fig. 5.

$C_o = 0.0958$

$n_r = 1.25$ from Fig. 4

$u_{act} = 130$ cp without sand

$(u_{act})(n_r) = 165$ cp

$m = 0$

$$N_{Re} = 1.3258 \times 10^5 \frac{(1.06)(35)}{(5.01)(1.25)(130)} = 6.04 \times 10^3$$

$f = 0.0098$ from Fig. 6

$$dP = \frac{(29.314)(0.0098)(35)^2(4000)(1.06)2^5}{\pi^2 (5.01)^5}$$

$= 1540$ psi

A comparison of this dP to that calculated under similar conditions for a gel discloses the greater friction encountered with refined oils. For other values of the variables, this difference may be even more magnified.

C. Emulsions: Assume identical conditions in this case with those in A and B above except the specific gravity was measured as 1.01 gms per cc and the viscosity was determined to be 500 cp at a shear rate of 1 ft per sec and at the temperature of surface conditions. Slope of the viscosity vs shear rate curve is –0.85.

$p = 1.00$ without sand

$p = 1.144$ with 2 lb of sand per gal from Fig. 5

$C_o = 0.0958$

$n_r = 1.25$ from Fig. 4

$u_{meas} = 500$ cp without sand

$(u_{meas})(n_r) = 625$ cp

$m = -0.85$ (The negative sign is corrected for in Equation 1)

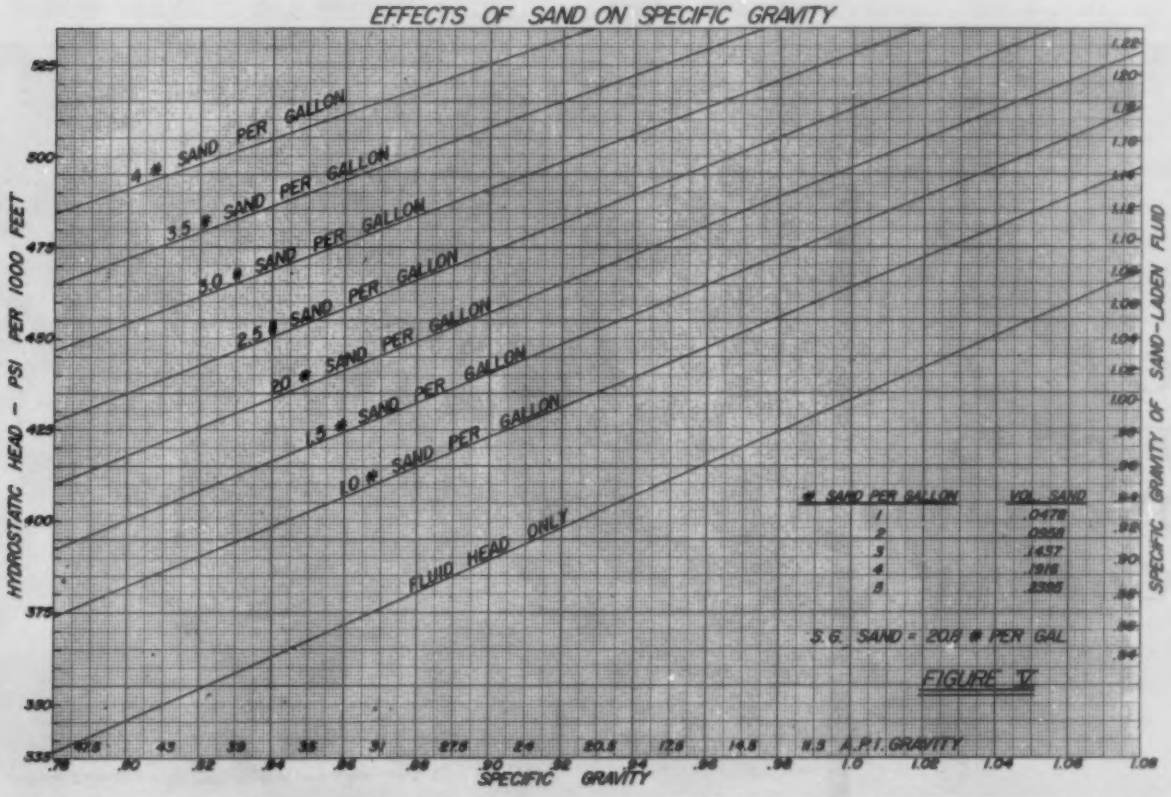
EFFECTS OF SAND ON SPECIFIC GRAVITY
HYDROSTATIC HEAD - PSI PER 1000 FEET
SPECIFIC GRAVITY OF SAND-LADEN FLUID
SPECIFIC GRAVITY
A.P.I. GRAVITY
4 # SAND PER GALLON
3.5 # SAND PER GALLON
3.0 # SAND PER GALLON
2.5 # SAND PER GALLON
2.0 # SAND PER GALLON
1.5 # SAND PER GALLON
1.0 # SAND PER GALLON
FLUID HEAD ONLY
SAND PER GALLON
VOL. SAND
S.G. SAND = 20.8 # PER GAL
FIGURE V

FIG. 5. **Effects of sand on specific gravity** of resulting mixture for various concentrations of sand. Hydrostatic head of resultant mixture shown in psi per 1000 ft of head.

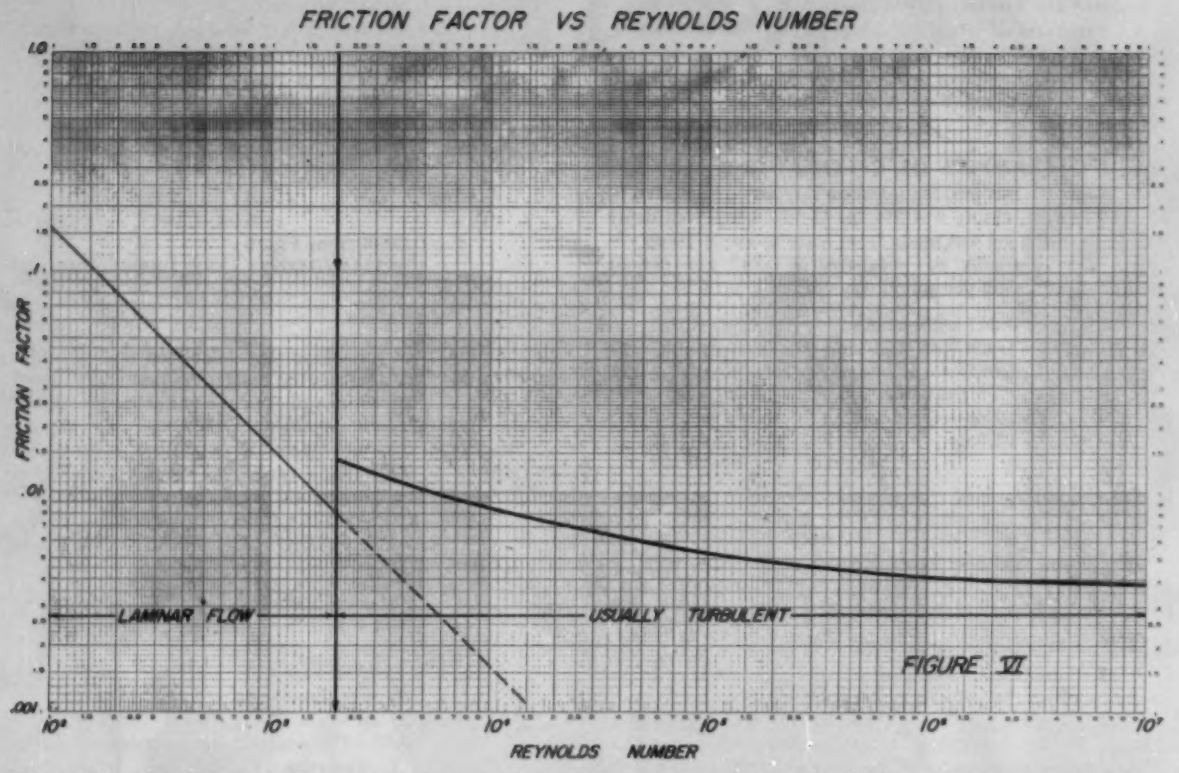

FIG. 6. **Friction factor** may be determined from this curve when the Reynolds number is known. Note range of laminar and turbulent flow.

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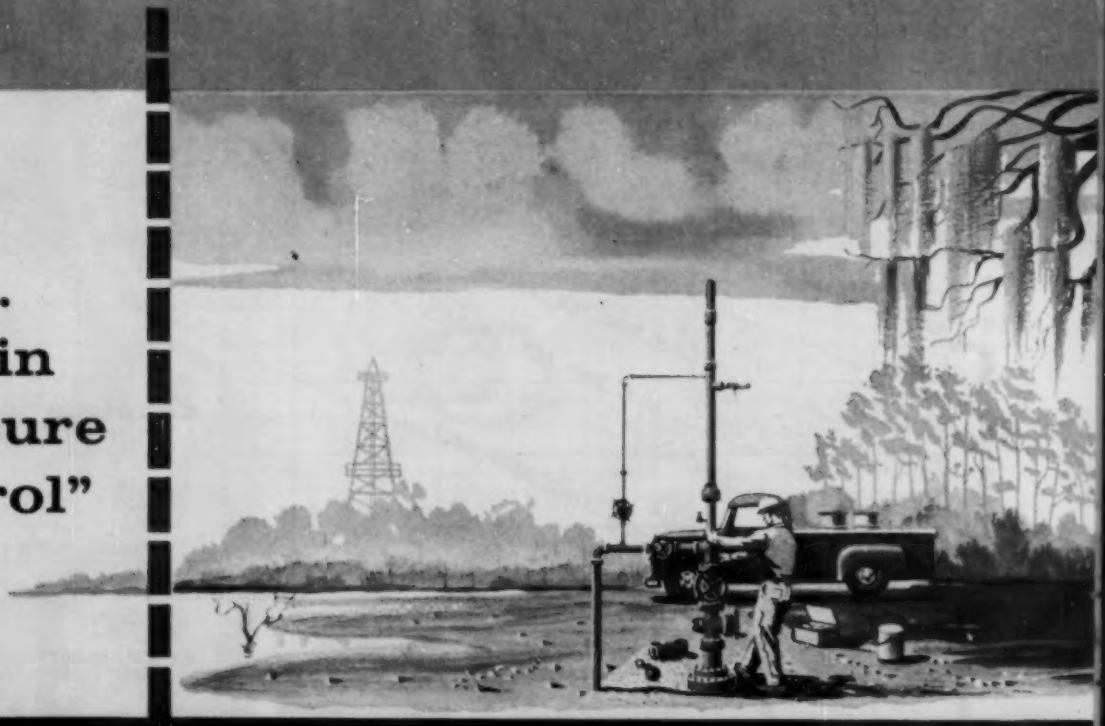

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$$N_{Re} = 1.04 \times 10^5 \frac{(1.144)\ (4 \times 35)^{1+m}}{(5.01)^{1+2m}\ (1.25)\ (500)\ \pi^{1+m}}$$

$$= 1.04 \times 10^5 \frac{(1.144)\ (44.5)^{1.85}}{(5.01)^{2.7}\ 625} = 2.34 \times 10^5$$

$$f = 0.013 \text{ from Fig. 6}$$

$$dP = \frac{(29.314)\ (0.013)\ (35)^3\ (4000)\ (1.144)\ (2)^5}{(\pi)^2\ (5.01)^5}$$

$$= 2230 \text{ psi}$$

The above value of dP was calculated on a simulated basis for comparative purposes with A and B. Viscosity and the m value were taken from laboratory information, and these values may or may not always correspond to those observed in the field. At the present time field data is meager, but when more data is acquired this additional information also will be published with the necessary corrections, if any, integrated.

USE OF FRICTION LOSS DATA

In order to make the horsepower allocaton the accurate knowledge of dP is applied to the equation

$$P_s + P_H - dP = P_B \quad . \quad . \quad . \quad . \quad (5)$$

where P_s is the surface pressure, P_H is the pressure caused by the hydrostatic head, and P_B is the bottom-hole pressure. The P_B has to be synonomous with P_{FB} (formation breakdown pressure) for a fracture to result, and the P_{FB} is assumed to be the maximum value for P_B during fracture extension. Hence, Equation 5 may be changed to read:

$$P_s + P_H - dP = P_{FB} \quad . \quad . \quad . \quad . \quad (6)$$

The hydrostatic head is readily calculated from Equation 3, and P_{FB} is taken from Fig. 7. This establishes the necessary P_s value for a fracture to result. Then, using the specified values for the injection rate and P_s and applying them to Fig. 8, the necessary horsepower is determined.

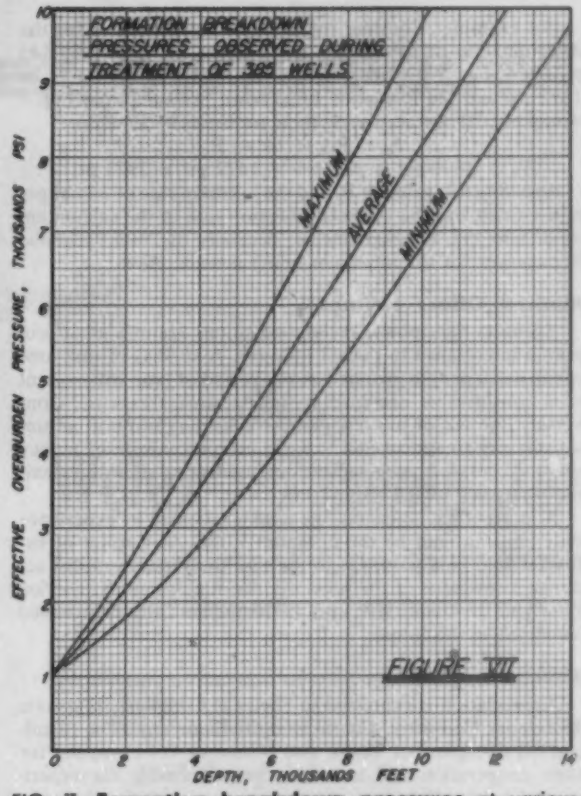

FIG. 7. **Formation breakdown pressures** at various depths to 14,000 ft, showing the average between minimum and maximum.

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For example: Consider the example calculation A for the determination of dP. In this instance the dP value was 845 psi, from Fig. 5 the hydrostatic head for the crude would be 1472 psi and the formation breakdown pressure from Fig. 7 would be 3600 psi. Equating these pressures by Equation 5

$$P_s = P_{FB} + dP - P_H$$

$$P_s = 3600 \text{ psi} + 845 \text{ psi} - 1472 \text{ psi} = 2973 \text{ psi}$$

Applying this value of P_s and the injection rate of 35 bbl per min (which was the assumed injection rate of the calculation of dP) to Fig. 8 designates the necessity of 2600 hydraulic horsepower for the treatment under consideration.

Method Offers Savings

Accurate horsepower recommendations are of a great economic importance to the oil industry. A savings of only one pump truck per job prorated over a period of time will amount to a considerable decrease in well treatment expense. Conversely, the use of too few pump trucks may result in an unsatisfactory treatment and to some extent a misuse of money spent. Accurate horsepower recommendations allow the maximum return on each "fracturing dollar."

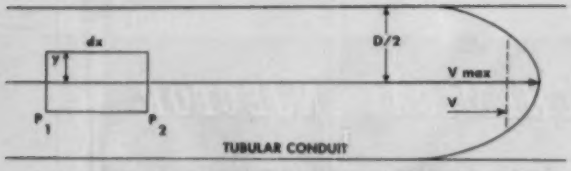
At present, the injection rate used is specified by experience only and may not be the optimum value. As a result of extended field data pertinent to the fracture radius and this accurate knowledge of the pressure loss, the optimum injection rate, and treatment size may be mathematically determined sometime in the future.

Acknowledgment

Appreciation is expressed to Shell Oil Company, Magnolia Petroleum Company, Continental Oil Company, The Standard Oil Company of Texas, and Monterey Oil Company for their cooperation and assistance in performing the experimental bottom-hole pressure surveys necessary for the compilation of data. Appreciation is also extended to the research, operations, sales, and wire line departments of The Western Company for advice, assistance, and cooperation on this project.

APPENDIX

Derivation of Friction Loss Equation



Equating the forces on the increment indicated:

$$dP\, y^2\, \pi = 2\, \pi\, y\, T\, dx$$

where $T = u \dfrac{dV}{dy}$

$$\frac{dp}{dx} y = 2\, u \frac{dV}{dy}$$

$$\frac{dP}{2\, u\, dx} y\, d\, y = dV$$

$$\frac{dP}{u\ dx} \frac{y^2}{4} = V + C$$

Evaluating C from the boundary conditions:

$$y = D/2\,;\ Vy = O$$

$$C = \frac{dP}{4_u\, dx} \frac{D^2}{4}$$

$$V = \frac{dP}{4_u\, dx} y^2 - \frac{D^2}{4}$$

or

$$4V\, u \frac{dx}{dp} = \left(y^2 - \frac{D^2}{4} \right)$$

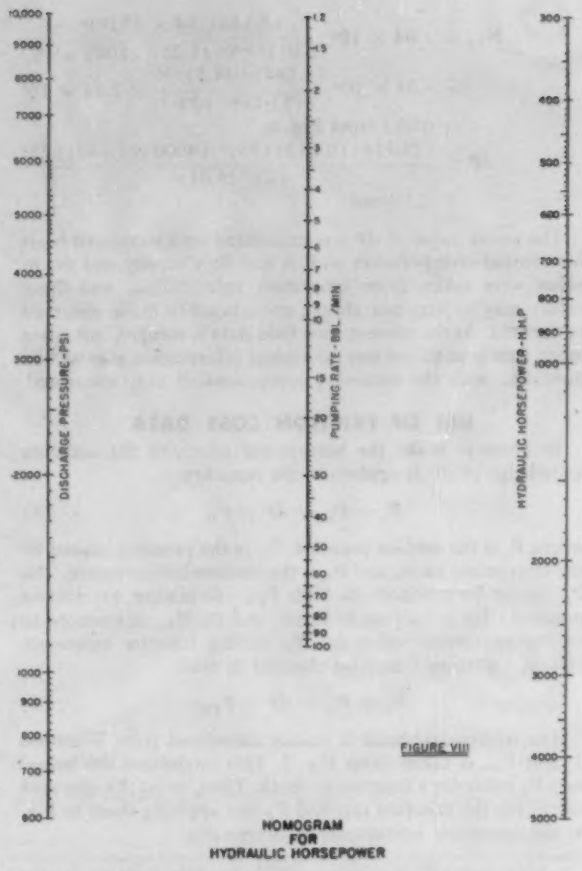


FIG. 8. **Hydraulic horsepower** supplied at the surface can be determined from this nomograph if the discharge pressure and pumping rate are known.

The right side of the equality is the equation of a parabola having its vertex on the center line of motion; hence, at the point y = O, velocity is a maximum.

$$V_{max} = \frac{-D^2}{4} \frac{dP}{4\, u\, dx}$$

$$V_{max} = \frac{-D^2\, dP}{16\, u\, dx}$$

$$-dP = P_2 - P_1$$

$$dp = P_1 - P_2$$

$$V_{max} = \frac{D^2\, dP}{16\, u\, dx}$$

From the geometry of parabolic flow:

$$V = \tfrac{1}{2}\, V_{max}$$

then: $$V = \frac{D^2\, dP}{32\, u\, dx}$$

$$Q = V\, A$$

$$Q = \frac{\pi\, D^4\, dP}{128\, u\, dx}$$

Integrating dx between the limits of L and O

$$Q = \frac{\pi\, D^4\, dP}{128\, u\, L}$$

This equation is simply the standard Poiseuille equation for

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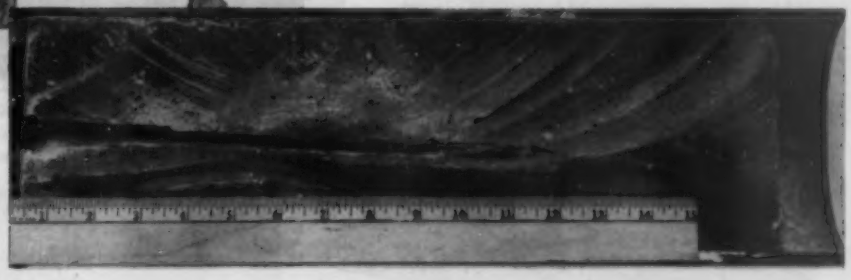

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newtonian fluids in laminar flow. Modifying the equation to non-newtonian fluids in turbulent flow:

$$fQ = \frac{\pi D^4 dP}{128 u L} f$$

$$\text{where } f = \frac{16}{N_{Re}} \text{ and}$$

$$N_{Re} = \frac{D V p}{u}$$

$$fQ = \frac{\pi D^4 dP}{128 u L} \frac{16 u}{D V p}$$

$$fQ = \frac{\pi D^3 dP}{8 L V p}$$

$$fQ = \frac{\pi D^3 dP A}{8 L Q p}$$

$$fQ^2 = \frac{\pi D^3 dP \pi D^2}{32 L p}$$

$$dP = \frac{32 f Q^2 L p}{\pi^2 D^5} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

This is the Fanning equation for newtonian fluids in turbulent flow. Correcting for the non-newtonian properties of the fluid, the following equation was substituted into the equation for N_{Re}:

$$u_{act} = V^m u_{meas} n_r$$

Since m is either zero or has a negative value,

$$u_{act} = \frac{u_{meas}}{V^m} n_r \quad . \quad . \quad . \quad . \quad . \quad (1)$$

$$\text{Then } f = \frac{n_r \ 16 \ u_{meas}}{D V^{1+m} p} \text{ for laminar flow}$$

$$\text{and } f = .0035 + .264 \frac{(u_{meas} n_r)^{.42}}{(D V^{1+m} p)} \text{ for turbulent flow.}$$

Changing Equation 2 into convenient units we have:

$$dP = \frac{95.176 f Q^2 L p}{\pi^2 D^5} \quad . \quad . \quad . \quad . \quad (3)$$

where dP is in psi, Q is in barrels per minute, L is in feet, p is in grams per cc, D is in inches, and f is the friction factor taken from Fig. 6. Then converting the equation for the Reynolds number into the same convenient units:

$$N_{Re} = \frac{D V^{1+m} p}{n_r u}$$

$$N_{Re} = \frac{D (Q)^{1+m} p}{n_r u (A)^{1+m}}$$

$$N_{Re} = \frac{D (4Q)^{1+m} p}{n_r u_{meas} (\pi)^{1+m} (D)^{2+2m}}$$

$$N_{Re} = 1.04 \times 10^5 \frac{(4Q)^{1+m} p}{\pi^{1+m} u_{meas} n_r D^{1+2m}} \quad . \quad (4)$$

Here, u_{meas} is in cp, n_r is dimensionless, and other units are identical with those in Equation 3 above. ★ ★ ★

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The slow speed (700 rpm), gives this Cooper-Bessemer FMP compressor the stamina needed for continuous operation. Heavy duty poly V-belt drive, 300 H.P. per frame, oversize bearings, are other examples of traditional Cooper-Bessemer quality.

ENGINEERING —
Southwest engineers have designed and built the best low horsepower packaged compressor. It is the rugged, high quality unit in the field.

Here is the heavy duty gas compressor the industry has needed. Not a stripped down model, but a rugged packaged plant designed and built with the same thoroughness that Southwest puts in its larger units. The Cooper-Bessemer compressor cylinder has interchangeable liners and is interchangeable with larger compressors. The same vertical air discharge cooling is used as in integral packaged gas compressor plants. The engineering design features proved by Southwest in integral units are incorporated in this, the first quality packaged gas compressor in the low horsepower field.

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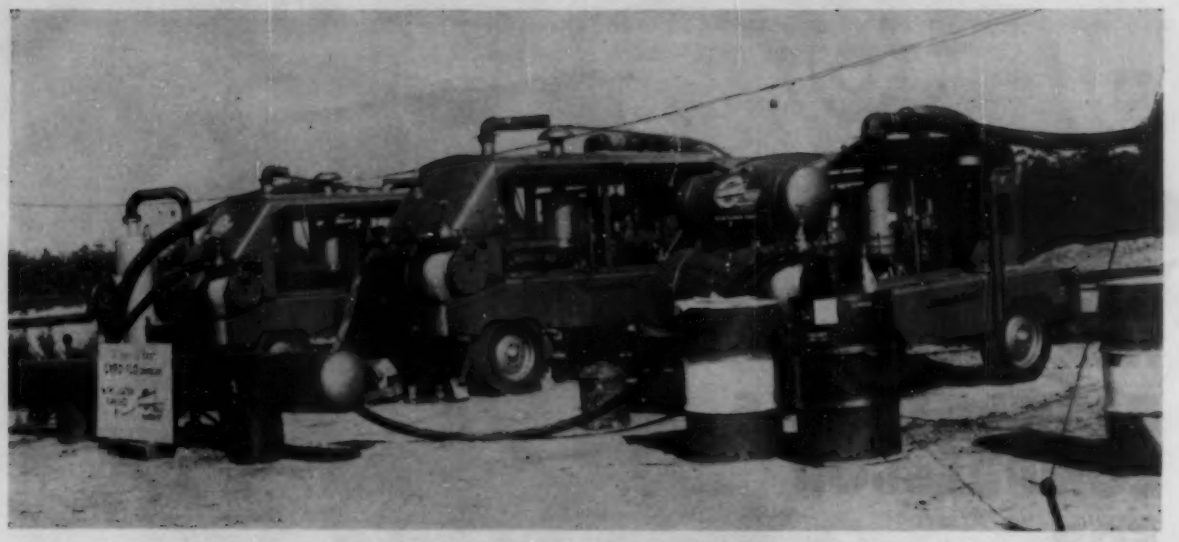

FIG. 1. **Three rotary compressors** in parallel operation are manifolded into a common receiver tank and wheel mounted for complete mobility.

DESIGN APPLICATIONS For Air Drilling Equipment

Correct application of compressor equipment on the market today is the air drilling industry's basic problem. Although manufacturers are meeting current needs for various types and arrangements of equipment, an entirely new field for design and invention is wide open.

V. A. La Fave
El Paso Natural Gas Company

AIR as a circulating medium to accelerate rotary drilling speed is rapidly gaining in favor. More attention is being directed to the compressor equipment now available to the drilling industry. Little, if any, knowledge has been presented on what manufacturers are offering to meet the needs of this rising drilling medium, and there has been little thought of analysis as to whether these demands are being adequately satisfied.

Now is the time to analyze the air drilling problems in light of air drilling experiences. A point has been reached where types and arrangements of air drilling equipment have been at least partially solved. The existing problem for the industry lies in the new field for design and invention and in the correct application of equipment now in use.

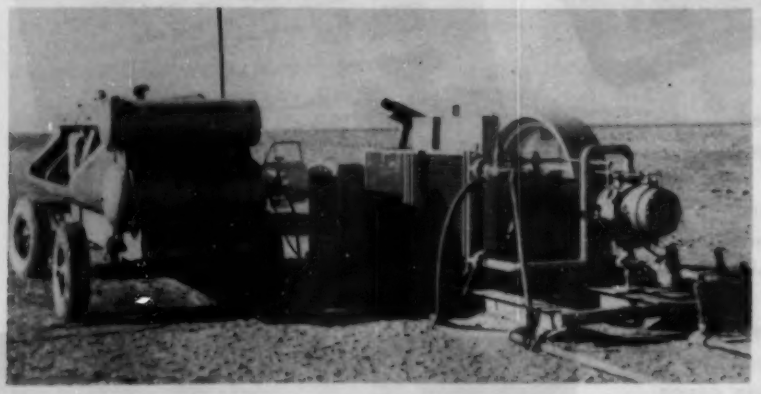

FIG. 2. **Reciprocating booster** is connected to this rotary compressor to provide higher air pressures than is possible with compressor alone.

Types of Compressors

Essentially there are only two types of compressors being used for air drilling operations. These are the reciprocating and rotary-type compressors. With the reciprocating compressors.

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Power take-off K-201 holds axle loads to minimum. May be mounted as shown, or immediately behind cab.

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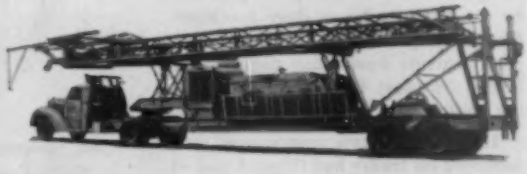

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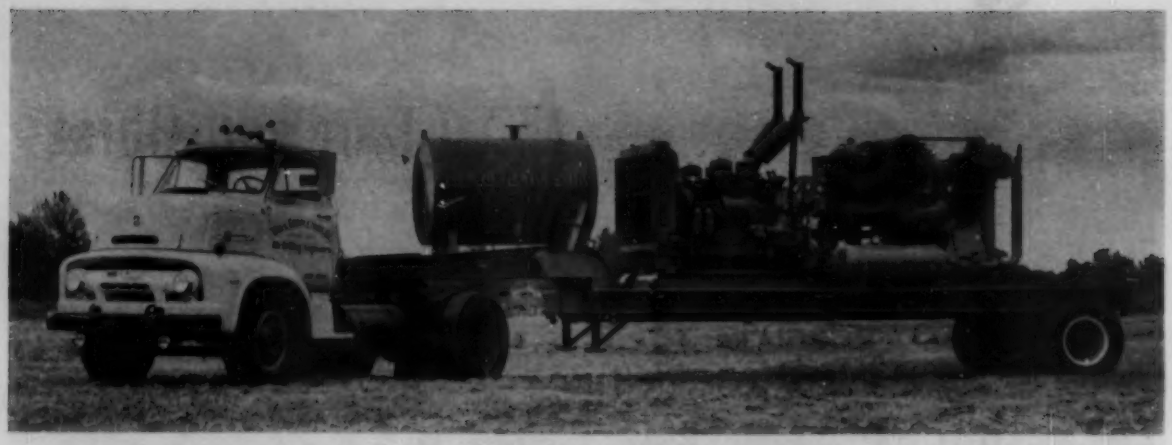


FIG. 3. **High mobility** is achieved in a trailer mounted compressor unit such as this. Setup consists of a two-stage compressor with intake air filter, inter-cooler and after-cooler, driven by a standard, industrial, high speed type engine.

high pressures can be achieved by multi-staging. The two-stage compressor has been the most popular, and it is being offered complete with intake air filter, inter-stage and after-cooler, all mounted as a packaged unit. Rotary compressors that can be mounted on skids or on wheels are being used in parallel operation where high volumes and low pressures are considered satisfactory for drilling (Fig. 1). These compressors are capable of pressures of 100 and 110 psig. When higher pressures are required, a reciprocating booster may be connected on the discharge side (Fig. 2). At present, there is experimentation with a three-stage rotary, skid-mounted unit, complete with drives, inter- and after-cooler.

Arrangement of Equipment

In the arrangement of air drilling equipment, manufacturers have attempted to reduce as much as possible the weight and size of their units. This has been a very difficult task as the equipment they are using can generally be classified as heavy-duty machines. Generally speaking, the following four arrangements have been presented as being the most feasible for air drilling equipment:

1. Engine-driven compressor units mounted on trailer bed (Figs. 3 and 4). This type of an arrangement is most satisfactory for use in a wildcat area where the required pressures and capacities for optimum drilling have not been determined. It consists of a two-stage air compressor with intake air filter, inter-cooler and after-cooler, driven by a standard industrial, high speed type engine. All of this equipment is mounted on a heavy trailer-type skid, complete with its own fuel tank. It has high mobility as far as size and weight are concerned. With this type of arrangement, it could be de-

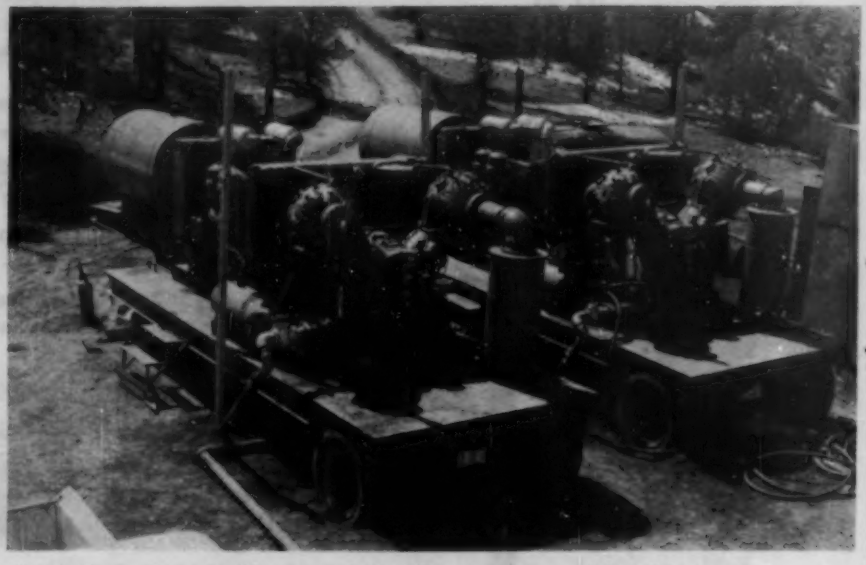


FIG. 4. **Two-stage trailer mounted units** meet the need in wildcat areas where required air pressures for drilling have not yet been determined.

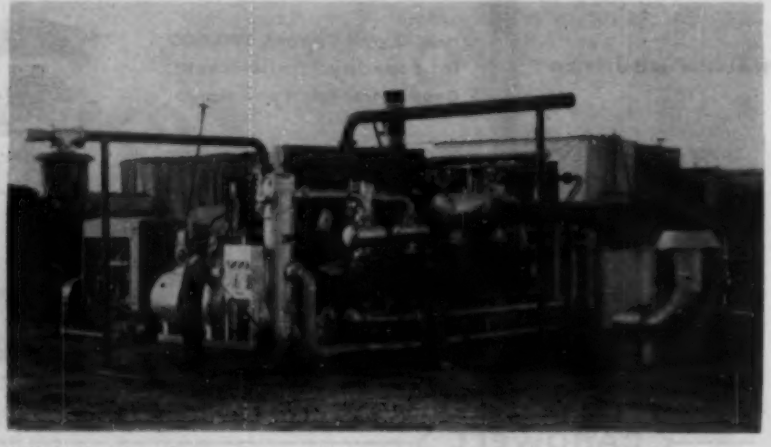


FIG. 5. **Large, three-stage** skid mounted units provide combined large volumes and high pressures.

cided whether air is feasible for drilling and, if so, the required amount could be determined. These units are designed for approximately 750 cfm and a discharge pressure of 265 psig. At present, experimental work is being conducted on adding a booster on the inlet so as to raise the atmosphere pressure to approximately 10 psig. With this possible, this machine will be capable of delivering approximately 1050 cfm at a discharge pressure of 125 psig.

2. Skid-mounted engine-driven compressors. Large volume, high pressure units can be skid-mounted (Fig. 5); but the smaller volume, high pressure machines are becoming more popular in the drilling industry (Figs. 6 and 7). The equipment arrangement of these units is the same as the trailer-mounted units. Any number of these units can be placed in parallel operation to satisfy the volume of air required. A decided advantage is that if one unit is down for repairs, only a slight reduction in capacity will be experienced. They are designed for 500 cfm each and with pressure steps from 150 to 350 psig.

3. Compound-driven compressors (Figs. 8 and 9). This arrangement consists of a skid-mounted, belt-driven compound drive with two-stage oil field type compressor units. Each compressor unit is mounted on an oil field type skid with combination jacket water cooler, inter-cooler and after-cooler. These compressors are driven by a heavy-duty chain drive mounted on an oil field type skid, with gear type oil pumps for lubrication of chains and bearings. Each compressor is bolted to the compound skid and doweled for field alignment. Each compressor unit is equipped with an air clutch and a hand operating valve for the air clutch. The entire compressor unit can be dropped out of operation by means of the clutch on the rig in the same manner that the mud pump is stopped. The air piping is permanently mounted along with the compound skid floor. This type of an installation can take the place of one of the mud pumps. In the event mud circulation is required, this compound could be clutched out and the mud pump put in operation. A decided advantage in this installation is that it can be broken down into several sections for ease of shipment. Also, additional compressors can be added to the compound drive if more capacity is required.

Each of these two-stage compressors is designed for 500 cfm and a discharge pressure of 250 psig. At 250 psig discharge, each unit would require approximately 200 hp.

4. Compressors directly driven by V-belt from rig engine (Fig. 10). This type of arrangement has several compressors connected in such a manner so as to receive their power from a common shaft. Generally speaking, this arrangement is used for compressors of low discharge pressure. If higher pressures are desired, a small booster unit may be installed. These

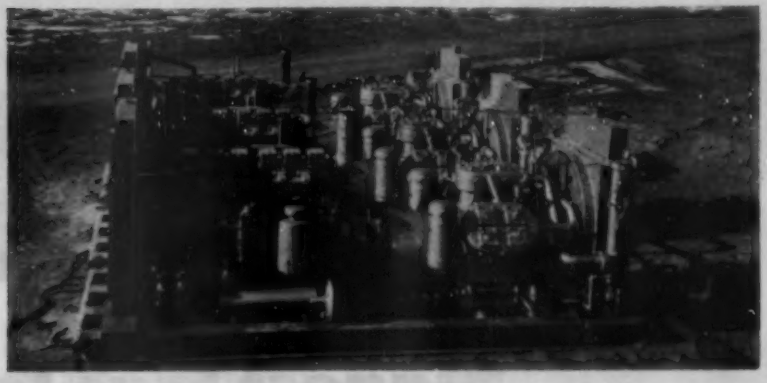
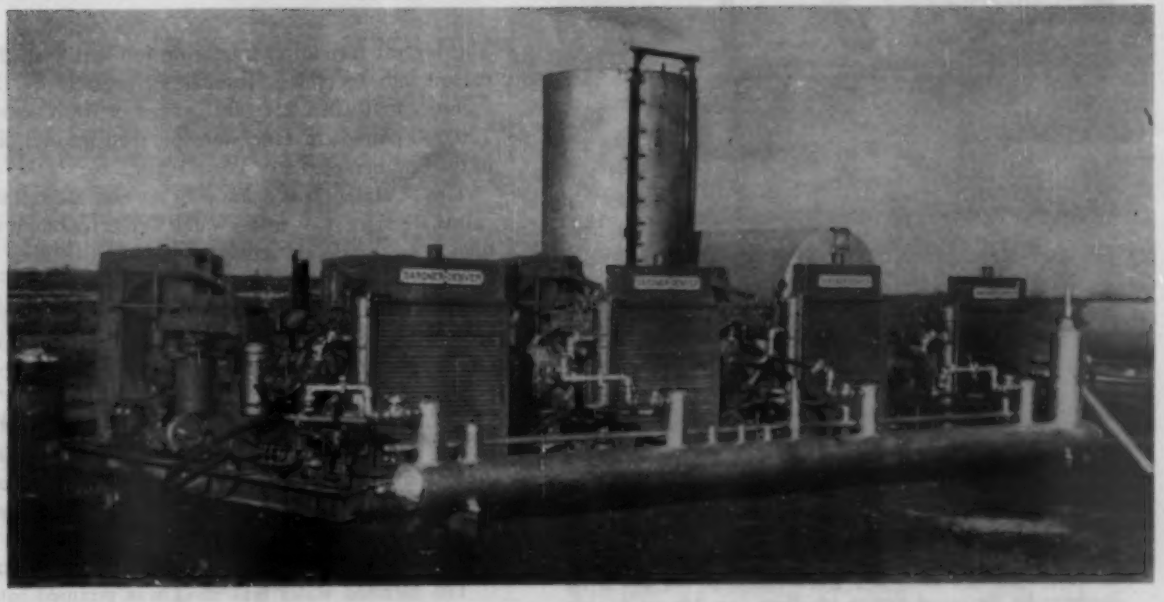
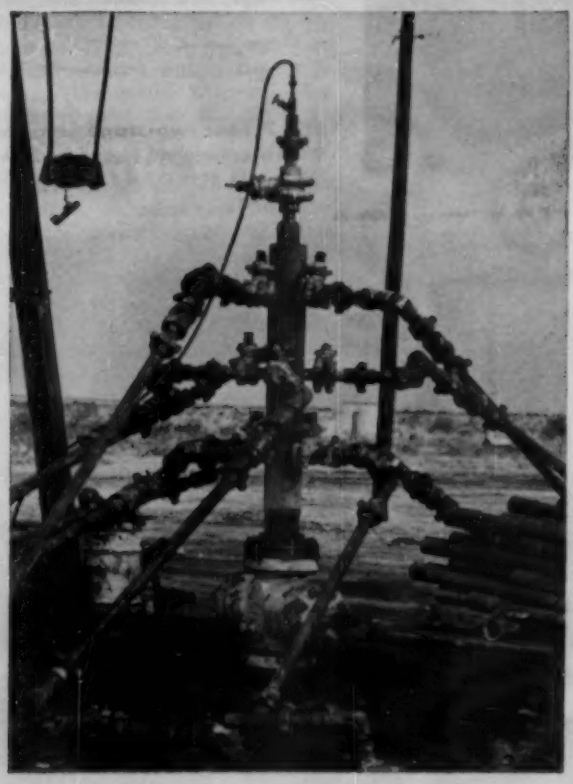


FIG. 6. **Popular** in the drilling industry are the small volume, high pressure two-stage, skid mounted units.

FIG. 7. **Four two-stage units** shown here are designed to deliver 500 cfm each with pressure steps from 150 to 350 psig.





Ten connections were made to a special header on this well in the Spraberry for the record fracture job. These lines fan out to eight pumping units which were positioned about 40 yards from the well.

Biggest Frac Job

The biggest formation fracturing job in the history of the oil industry was accomplished recently by Dowell Incorporated when 250,000 gallons of fresh water and 200,000 pounds of sand were pumped into an oil well in the Spraberry area of West Texas.

This treatment was made with the new Dowell service called Riverfrac® — using water as the frac fluid rather than lease crude or refined oil. No thickening agent was used.

As an indication of the magnitude of the job, 18 mobile Dowell units were used. The pumping trucks alone generated more than 7000 engine horsepower. Hydraulic horsepower totaled 4500.

Two blenders to mix the sand and water, eight sand trucks, eight truck-mounted pumping units and several pieces of auxiliary equipment were required. Four of the units were the new Allison pumpers which employ aircraft power to give high injection rates. Two units were diesel pumpers and two were "super Continentals".

The blended water and sand was pumped into the Spraberry formation at an average injection rate of 52

in History . . . *another* DOWELL *first*

barrels, or 2184 gallons a minute. Surface working pressure was 3400 pounds per square inch.

The well which received this record-breaking treatment was completed at 7767 feet for a good flow of oil in 1953. Its production declined characteristically, and it was pumping 27 barrels a day when taken off production for this treatment.

The previous record fracture treatment was established by Dowell in the McCamey Pool when close to 100,000 gallons of water was injected.

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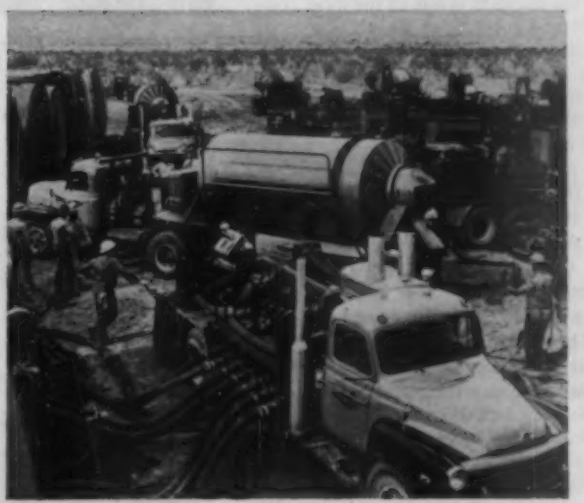


Here is the "working area" for the record fracture job. In the foreground is one of two blender trucks which mixed the water and sand. In the center is a sand truck. Tanks which held the water are at left. Dowell's remote-controlled, Allison-powered pumpers are shown at right.

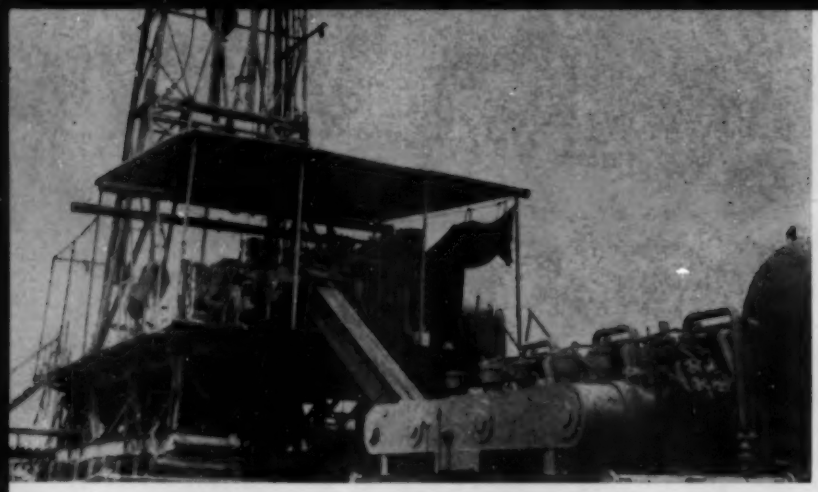


FIG. 8. **Compound driven compressors,** such as these, are of the two-stage oil field type. Combination jacket water cooler, inter-cooler and after-cooler are attached to compressors driven by heavy-duty chain drive, all on a common skid.

FIG. 9. **Installation** of the compound-driven compressors can be made simply by taking the place of one of the mud pumps. Entire compressor unit can be dropped out of operation by means of a clutch, in the same manner that the mud pump is stopped.

units are designed for 600 cfm and a discharge pressure of 110 psig. It is possible for these units to go to a higher pressure, but the capacity output would be reduced. At 110 psig discharge, each unit requires approximately 160 hp.

As a matter of interest, equipment manufacturers have done a remarkable job in assembling units for air drilling from existing equipment. Particularly this is true since much of the time they were working in a field where there was little or no available data.

Capacity and Pressure

In this regard, one question that was raised at the beginning and one that is still being raised is: What are the pressure and capacity requirements needed for compressor equipment for air drilling?

Obviously, before manufacturers can design new units, they need to know more fully what is expected of the equipment.

This question is one of the most controversial subjects in air drilling technique, and one which may be impossible to answer directly. It is difficult to predict what type of equipment is needed for any one drilling location or operation.

Curves have been calculated showing the required pressure and capacity for compressors for certain depths using a constant velocity. These curves are ideal in theory and may well be correct; however, the variables that exist are too numerous.

The industry is necessarily vague in what it expects of compressor equipment because of these variables:

1. Character of formation — from the hard, dry, consolidated types of formations that favor air drilling to those of a sloughing or caving type which become problems in air drilling.

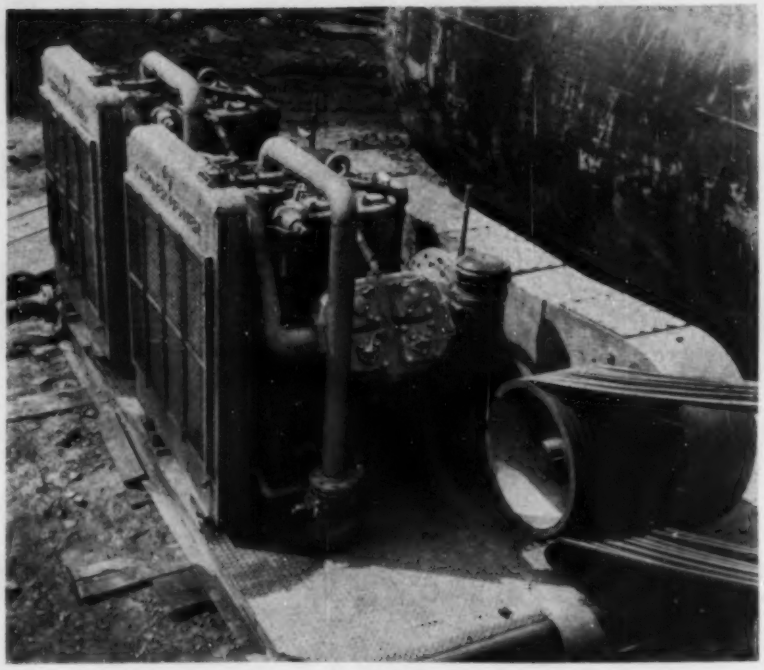
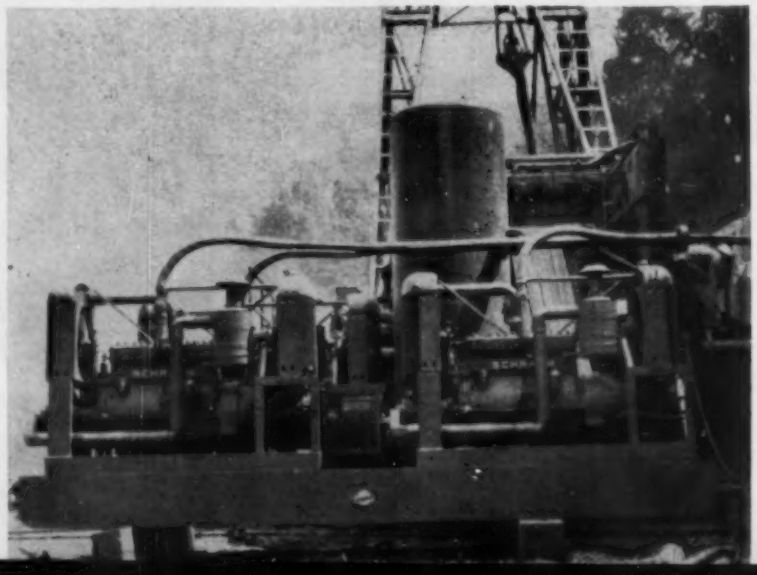


FIG. 10. **Rig Engines** drive these compressor sets directly through V-belts. This arrangement is usually used for compressors of low discharge pressure.



2. The amount of fluid entering the hole.
3. Size and shape of drill cuttings.
4. Size of hole and drill pipe size.
5. Pressure losses through air piping system.

Of these, character of formation and fluid entry have been the two most unpredictable variables that have affected compressor equipment.

It appears that every area has its own air drilling problems and in turn has its own capacity and pressure requirements for air drilling.

Rent or Purchase

It is obvious that any type of equipment that is now available is expensive, and for that reason industry is confronted with the problem of whether it is better to buy or rent equipment.

A drilling company who plans to explore an unproven area and who intends to try air as a circulating medium in drilling may wish to look into the advantages of using a service unit, before purchasing equipment.

Four important factors to consider are:

1. The frequency in which air drilling is to be used or number of wells to be drilled in the area.
2. The amount of volume and pressure that will be required.
3. The arrangement of equipment as to number of units and their method of drive.
4. The availability of personnel familiar with air drilling.

In those instances where El Paso has used compressed air in drilling, equipment has been rented from one of the several service companies in business. Since 1951, El Paso Natural Gas Company has drilled or partially drilled seven wells using compressed air, but has not conducted any experimental work in air drilling.

Service Companies

There are service companies who offer trailer-mounted and skid-mounted compressors, complete with operator, on rental basis. They offer a type of arrangement that can be connected up with the least amount of shut-down time. If necessary, two or more units can be hooked up for parallel operation. If the formations drilled are not favorable for air drilling, these units can be disconnected and their service terminated at a minimum cost to the company. If the area is favorable for air drilling, the required pressure and capacity can be determined from a pressure and flow recorder installed to operate on a flow line from these units. Once the maximum requirements have been determined, the drilling company can then either rent or purchase equipment necessary to fulfill their needs. The primary reason for using these trailer or skid-mounted units is to foresee if air is feasible and then determine from flow and pressure recordings taken while drilling, the maximum volume and pressure that is going to be required for the area which is to be drilled. These units offer extreme flexibility to the drilling company.

Several of the advantages they offer are:

1. A two-stage compressor capable of delivering high pressures. Additional units can be connected for parallel operation as extra volume is required.
2. A compressor unit mounted on a trailer for fast transportation, and completely unitized with fuel tank, cooling system, and engine.
3. The compressor remains on trailer and can be quickly manifolded into the rig circulating system.
4. Each unit can have its own experienced operator, if desired.

Conclusions

Air drilling experiences have reached a point where we feel that problems such as types and arrangements of equipment have at least partially been solved.

The remaining problem is what capacity and pressure are to be expected of this equipment.

Until more operational data is available, it is difficult to make specific recommendations that manufacturers can use for the capacity and pressure requirements of their equipment.

From El Paso Natural's experience in both air and gas drilling, we feel that we can recommend that if an air drilling unit is capable of delivering a capacity of approximately 3,000,000 cu ft per day of free air at a pressure of 125 to 150 psig and also a capacity of approximately 2,000,000 cu ft per day of free air at pressures from 300 to 350 psig, in most instances air drilling can be accomplished.

The equipment for air drilling, like all drilling equipment, is expensive; however, it is only a matter of time until some of the problems such as weight and size limitations have been solved and high capacity and high pressure machines have been designed.

After this, we may certainly expect to see a much greater demand for air drilling equipment.

The Author

V. A. La Fave is an engineer in the pipe line design and gas compression division, El Paso Natural Gas Company. His function is the design of gathering and transmission pipe line systems and the application of gas compression equipment.

La Fave attended Texas College of Mines and Metallurgy and was graduated in August, 1952, with a BS degree in mining engineering. Prior to his service with El Paso Natural Gas he was employed by a service company in the Permian Basin. His first assignment with El Paso was as an engineer in the mechanical design section. In October, 1955, he was transferred to the pipe line design and gas compression division.

Acknowledgment

The author would like to acknowledge the assistance given by the Drilling Department of the El Paso Natural Gas Company and to thank them for their cooperation in providing the necessary data to compile this report. This paper was presented at the Eleventh Annual Petroleum Mechanican Engineering Conference, ASME, Dallas, Texas, September 23-26, 1956.

★ ★ ★

Petroleum Branch Plans Big Fall Technical Program

The largest technical program on record is planned for the thirty-first annual fall meeting of the Petroleum Branch, American Institute of Mining, Metallurgical and Petroleum Engineers. Sixty-four papers will be presented October 14 through 17 at the Biltmore Hotel, Los Angeles.

The 15 technical sessions will include papers on nearly every phase of petroleum engineering. There will be an informal conference on electronic computing and special sessions on water flooding. Subjects of other half-day sessions include production equipment, model studies, well completion, reservoir engineering, gas technology, drilling equipment and procedures, fluid displacement research, new process and sources of oil production, drilling fluid technology, logging, and production research.

Three concurrent sessions are planned for the morning programs on October 16 and 17 and the October 16 afternoon program. Two concurrent sessions will be held during the rest of the program.

Top Petroleum Branch awards—the Certificate of Service and Ferguson Medal—will be presented at the Membership Luncheon. The Southern California Petroleum Section, AIME, will be host for this first major meeting of American petroleum engineers to be held in Los Angeles.

Power plant for all AC electric rig located in modified LST.

Delta Marine Drilling Commissions First Tender

THE drilling tender "Joseph Zeppa" was placed in commission by Delta Marine Drilling Company, following a christening ceremony at American Marine Corporation (formerly Alexander Shipyard) in August. It was named after the president of Delta Marine, and is the first tender of its type for the company.

A converted LST, the tender is a non-self-propelled vessel, measuring 328 ft by 50 ft by 28 ft. Principal feature of the tender is that all light and power is supplied to the tender and the drilling platform by an a-c electrical system. On the tender itself are installed the main power plant, main mud pumps, active and reserve mud pits, all drilling fluids, evaporator unit, cementing unit, bulk mud, cement, and chemical storage.

Fully air-conditioned, mahogany-panelled quarters are provided for 48 men and feature two recreation rooms, large cold-storage capacity, and ample galley and mess room. A four-man hospital is provided and a helicopter deck is located over the quarters.

In rig-up operation, the tender deck area accomodates all platform drilling equipment. The 30-ton stiffleg derrick is of ample capacity to handle all platform items, eliminating the necessity of employing the services of a derrick barge in either rigging-up or rigging-down. Two 10-ton cranes are also provided for easy handling of supplies from barges or supply vessels laying either port or starboard of the tender.

The power plant is unique for drilling operation in that a-c power is utilized in driving the mud pumps and drawworks. This application, drawing all of its power from a centralized plant, accomplishes speed and torque control by the use of d-c rectifier-supplied eddy-current couplings, thus introducing desirable recognized d-c motor characteristics into the large a-c motors.

The tender-platform arrangement has been designed with the purpose of presenting an efficient and economical method of drilling in the Gulf. Later this year, Delta Marine Drilling Company expects to commission an offshore submersible drilling barge which is presently under construction at American Marine Corporation at New Orleans. ★ ★ ★

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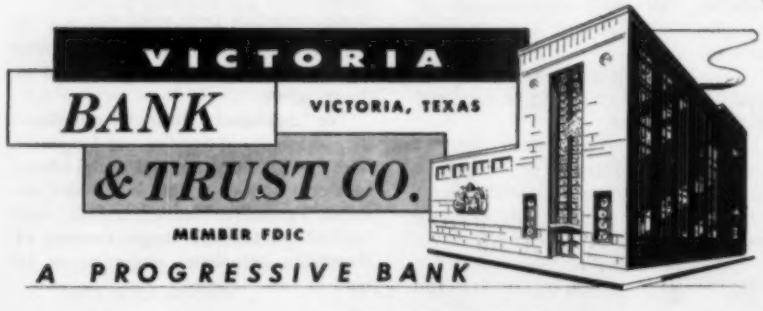

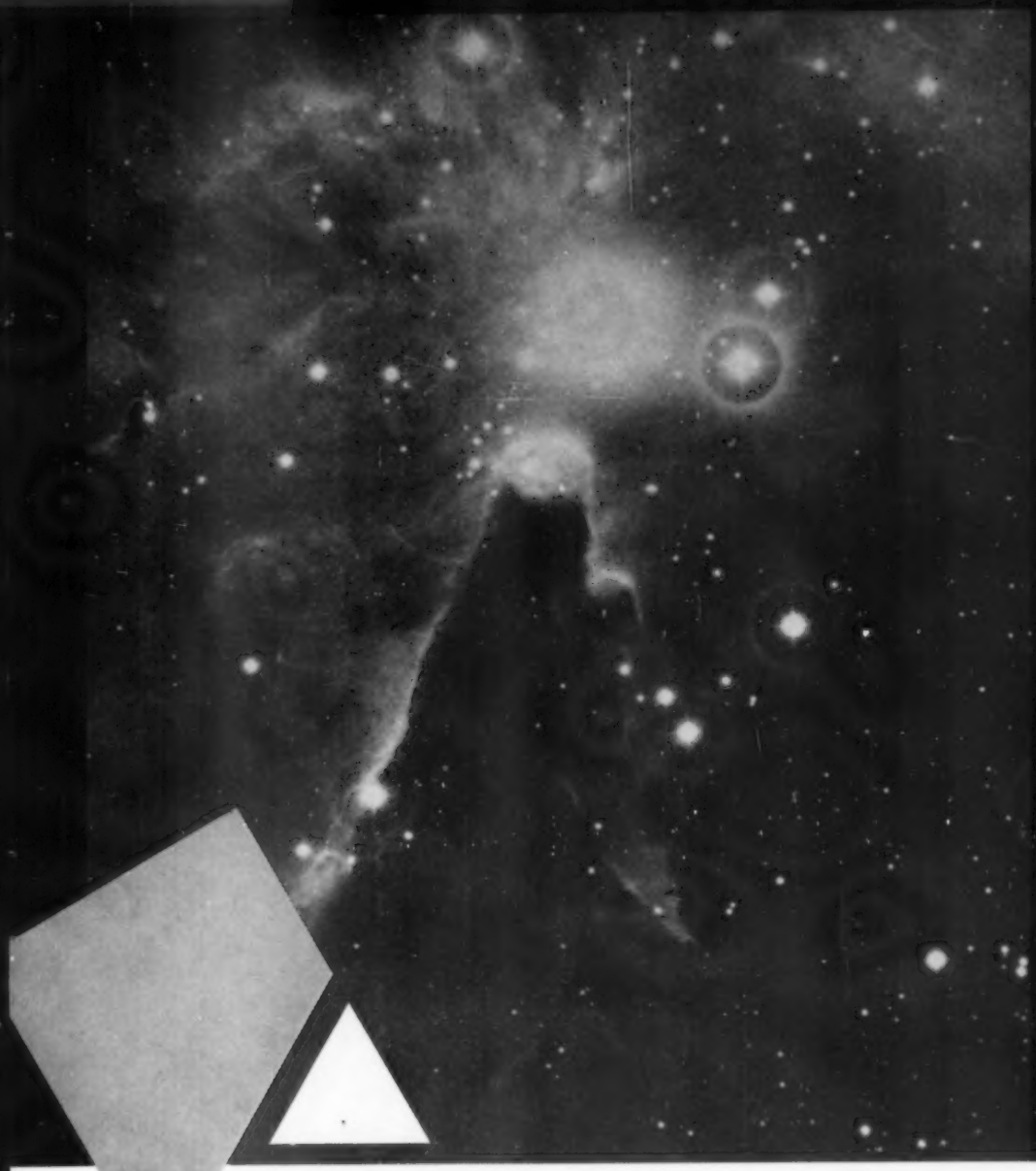

The "Cone Nebula" in the constellation of Monocerus photographed through the 200-inch Hale telescope of the Palomar Observatory. This mass of stars is about 1,000 light-years, or roughly six million billion miles from the earth.

MEASURING THE UNSEEN

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E. J. Dower

Warren Automatic Tool Company, Houston, Texas

WITH accurate measurement and proper interpretation, variations in mud pit level at times can be one of the most important variables to be checked on a drilling rig. If the driller understands what an observed variation in pit level means in terms of what is happening down the hole, this information is a powerful weapon against potential blowouts and stuck drill pipe.

Fractional variation in the mud pit level for a long time remained invisible to the naked eye. Large variations were, of course, visible but were hard to interpret accurately because of the difficulty of remembering or determining whether a similar change had occurred previously. Yet, from the days of the first rotary rig, it has long been recognized that the mud pit is the most obvious and direct place in which to observe a change in the total volume of mud in the drilling mud system. A change in the total volume of mud is important anywhere, but it assumes its greatest significance in areas of high pressure and/or thief formations.

Gradually, a few operators and contractors began to place a "measuring stick" in the mud pit as an aid to visual observation. A few also rigged up a "measuring stick" or a remote alarm system where the driller could see or hear it. Despite these innovations, it was not until the advent of continuous mud pit level recorders that a true study of mud pit level changes became either possible or practicable.

Level changes prior to trouble. It has been determined that in practically all cases of a blow out or threatened blow out there is a warning pit level change prior to the actual trouble. The first evidence of trouble may be recorded from one half hour to two hours before the most serious threat occurs, depending on drilling conditions and what remedial action, if any, is taken. In some cases, for example, a one-tenth of a foot rise in pit level may represent a serious salt water or gas incursion that could progress to blow out proportions if prompt and proper action is not taken. Similiarly, normal changes in pit level due to a particular drilling operation, such as the addition of weighting material, water, or jetting out shale, have previously made it difficult to determine accurately by visual observation what changes come from the well itself.

After several years study. The purpose here is to delineate the results of several years of study on mud pit level variations, a study that has been aided by use of actual recorded charts which are readable and accurate to one-half of one-tenth of a foot. Mud pit level variations must be interpreted accu-

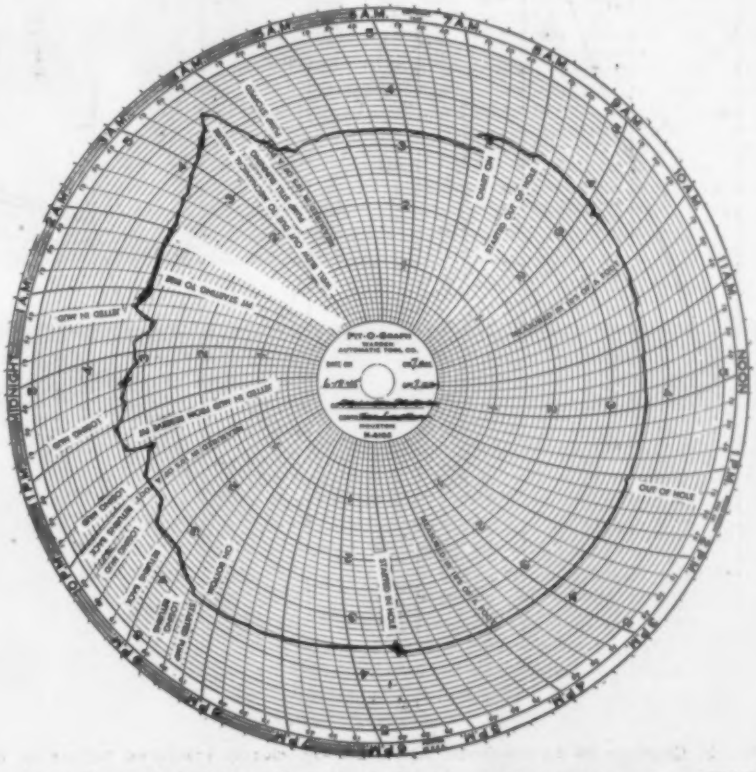


FIG. 1. **Recorded chart of mud pit level** variations with explanation of operation or condition which caused changes indicated.

rately. The chart provides the means of accurate interpretation. If weighting material or water is being added to the mud system, a proper interpretation of a change caused by a condition in the hole can still be made from the chart because of its fractional readability. A sample of the recorded chart is shown in Fig. 1.

It was stated above that a sudden rise of only one-tenth of a foot in the mud pit level could represent a serious situation in some cases. In other cases it may be insignificant. This will depend on the pit surface area, from which a volume can be easily approximated or calculated by the driller, and on the change in hydrostatic head which this volume represents in the annulus. Given the annulus area, and the calculated volume change in the mud pit, the change in hydrostatic head in the annulus can be closely approximated. The nomograph in Fig. 2 will greatly facilitate these calculations.

How to Use Nomograph in Fig. 2

The nomograph in Fig. 2 can be used to correlate the volume of a pit level change with the equivalent number of feet of annulus when two or more annulus areas are spanned by the volume under consideration. The following steps will clarify this procedure.

Step:

1. Connect pit width to pit length to obtain pit area.
2. Connect pit level change and pit area to obtain volume change.
3. Connect diameter of the lower portion of hole (plus any allowance for bit making over or undersize hole) with drill collar size to get lower annulus area.
4. Transfer this area to right hand annulus area scale.
5. Connect annulus area with previously determined volume change to obtain the equivalent feet of head.
6. If this head exceeds the total length of drill collars the volume in question extends into a larger annulus zone, the drill pipe being smaller. In this case, connect the first annulus area with the length of this size annulus and note the volume of this zone.
7. Subtract this volume from the change in volume found in Step 2 and obtain remaining volume which extends into zone 2.
8. Determine the second zone annulus area and connect it to the remaining volume to find the equivalent height in zone 2.
9. If this height does not exceed the actual height of this size annulus then add the two heights to obtain the total. If the change in volume extends into a third zone then repeat steps 6, 7, 8, and 9.

Note: Pump rate should be considered when the rise occurs over an appreciable length of time. The volume pumped during the period of rise should be added to the volume increase. This only has the effect of moving the added volume up the hole probably to a zone of larger annulus area. Unless a change in annulus area is encountered, the fact that mud and salt water are mixed has no effect on the hydrostatic pressure change. In a uniform column, the total head pressure is the same whether two liquids are mixed or stratified.

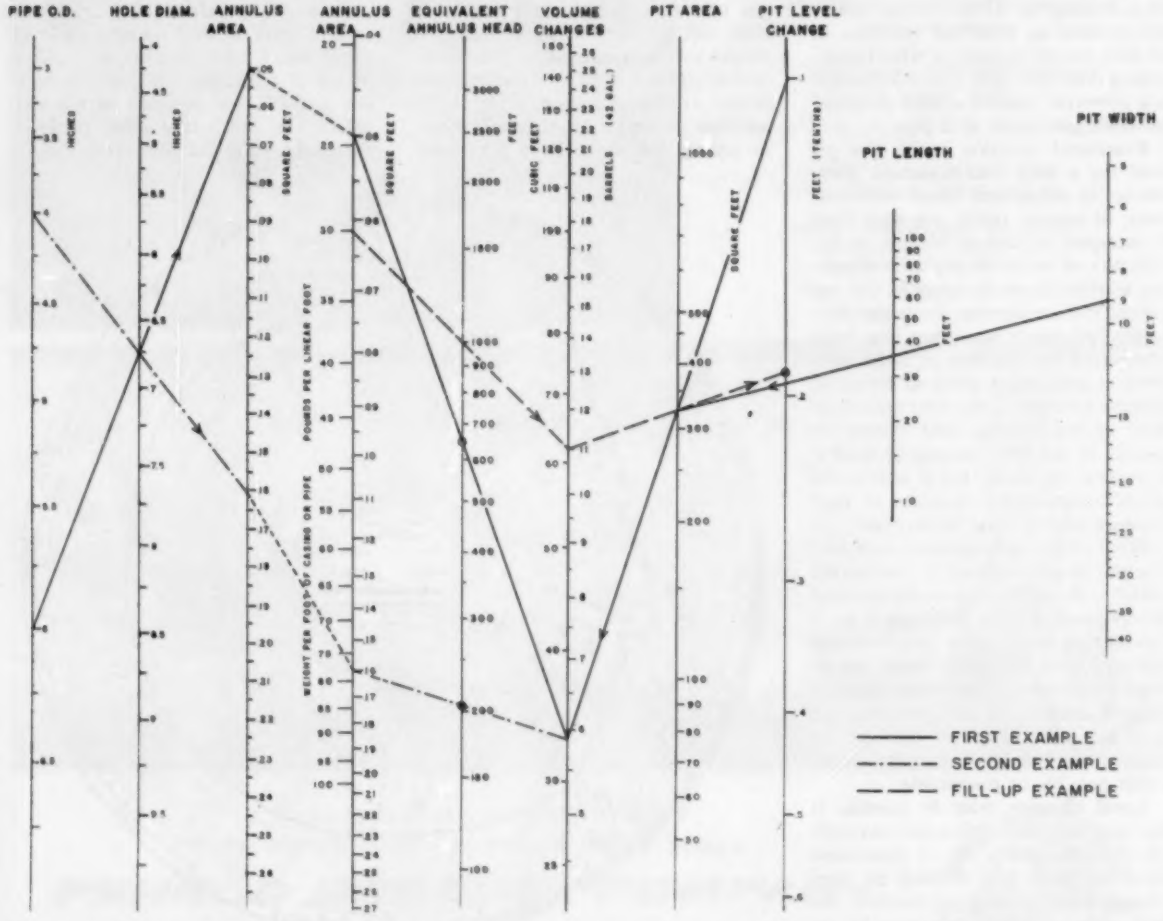
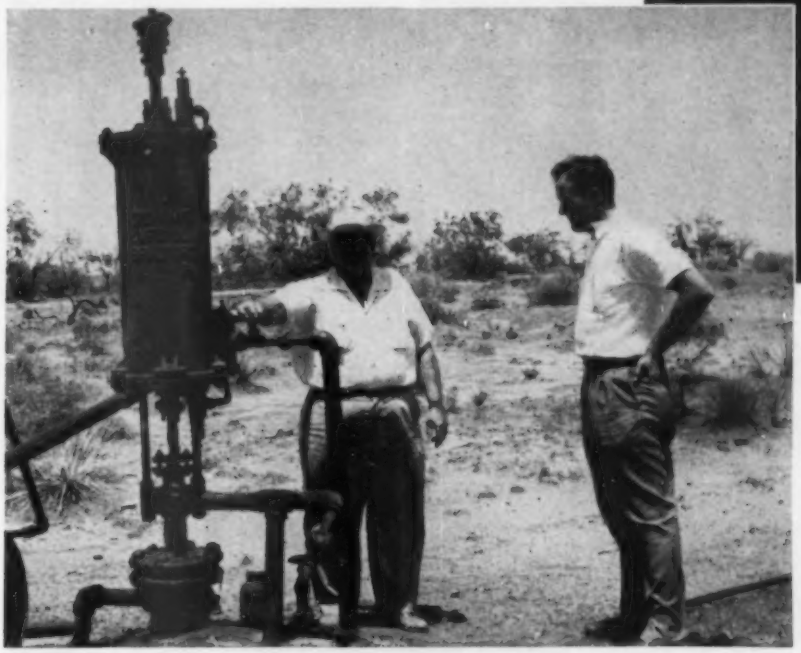


FIG. 2. **Change in hydrostatic head** can be closely estimated by use of this handy nomograph if other data are known.

AXELSON PICTORIAL

WISE GUYS: This pair of baby horned owls was found by Windy Greene, Store Manager for Jones & Laughlin at Russell, Kansas, and Jimmy Drake, Axelson Representative, during a week-end fishing trip on the Saline River. The birds were in a tree nest wolfing down a large jack rabbit that the mother owl had caught for them. They made an Axelson working barrel their perch in the pump repair shop at Russell. Living on hamburgers and raw beef liver, a bird collector from Great Bend took pity and gave them a home. They are now twice this size; each bird weighs over 20 pounds.



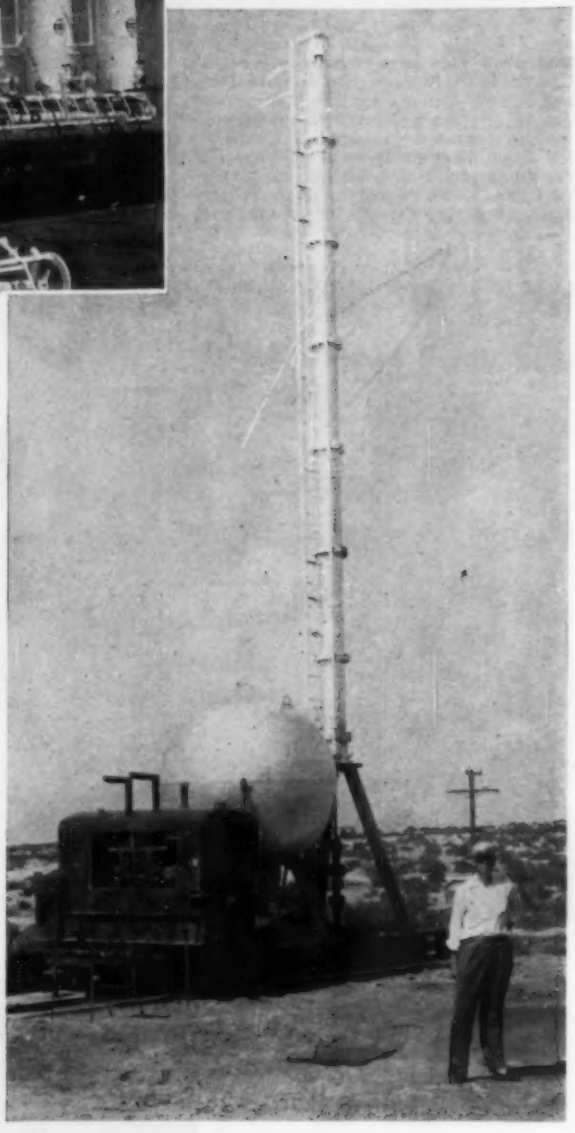
AIR LIFT. While drilling this well (McClure #1, Scurry County, Texas), a high-pressure gas pocket was hit at 1,200 ft. It was harnessed and used to actuate the sucker rod string through an "air-operated head." Air pressure is 200 psi, depth is 2,400 ft., production 4 B/D of 27 gravity oil. An Axelson 1½" bore Sure-Seal Pump has been in service for eight years without being pulled. L. M. "Woodrow" Wilson (l.) Production Superintendent for W. S. Guthrie Oil Company (producer) and Forest Goin, Axelson Representative, check pressure.

BUYERS' MARKET. Well known among oil men is Curt Oppel (center), Resident Purchasing Agent for the Atlantic Refining Company in their Dallas office. He is now in his thirtieth year with the Company. Flanked by his assistant, J. W. Crittenden (l.) and E. L. Chandler, Axelson Representative, Oppel has just signed an order for 40,000 feet of No. 60 Axelson Sucker Rods for East Texas wells.

AXELSON

USI

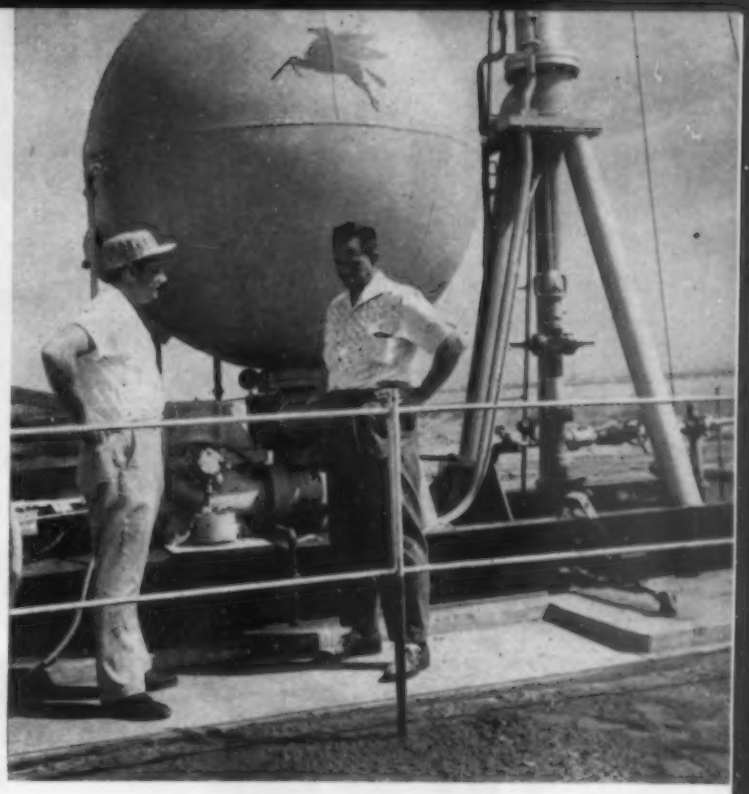
CARLOADINGS UP. These 10-foot counterbalanced units leaving the Axelson plant at Los Angeles are headed for the Dominion Oilfield Supply Company, Calgary, where they will be installed in Alberta's rugged Pembina Field. The newest addition to the line of Axelson hydraulic pumping units have an 18,000 lb. rod load capacity and can pump efficiently at eight strokes per minute.



DEFIES GRAVITY. About 30 miles south of Big Lake in Crockett County, Texas, this Axelson Long-Stroke Hydraulic Pumping unit raises sweet oil (39 gravity) from 6,200 ft. for Continental Oil Company. Five of the 40 producing wells in this water flood project (Todd-Crinodal) are equipped with Axelson Long-Strokers. Milton Barber, Project Engineer for Continental, in foreground.

6-FOOTER. Here on a stripper well near Kilgore, Texas, is a typical Hydrax hydraulic pumping unit. Jud Hemperly, Production Foreman for F. A. Fuller Company, checks the six-foot stroke length. He had an abrasive sand condition but the slow, smooth pumping cycle has reduced the fluid turbulence and ended this problem. This unit produces 32 gravity oil from a depth of 3,600 ft.

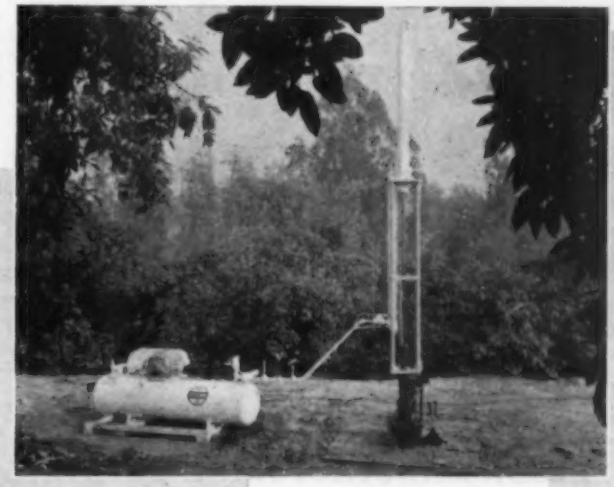
HYDRAULIC PUMPING. *On these two pages are illustrations of the four types of hydraulic pumping units that Axelson makes. They handle any producing depth from shallow, low-production pumpers to deep, high-volume wells. Stroke lengths range from four to 26½ feet. Some units are balanced, some are non-counter-balanced. Special units pump low viscous oil, multiple units pump from a single power source. Many are performing jobs economically that have never been done so before, without rod breaks and mechanical failures.*

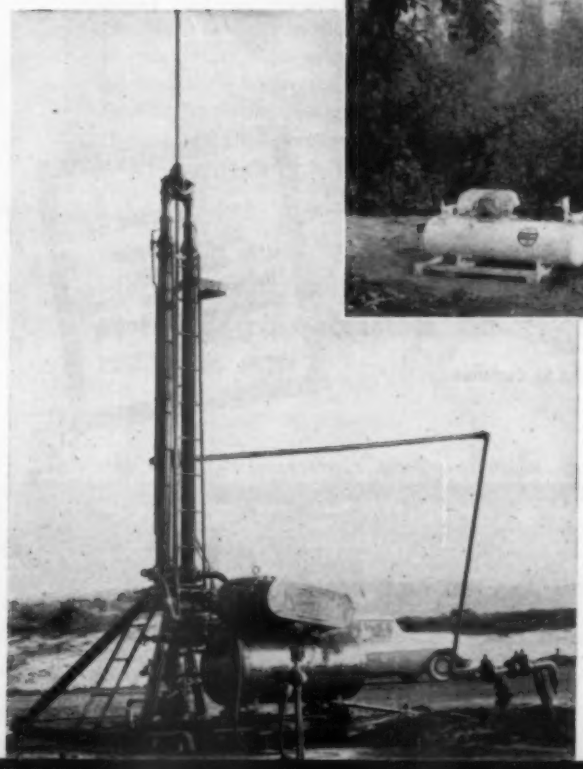


RIGSIDE. Magnolia Petroleum Company has 18 of these Axelson Long-Stroke Hydraulic Pumping Units on their Southeast Nolley Lease in Andrews County, Texas. In front of the E. E. Nolley #1 is Charles Hickok (l.) Magnolia Petroleum Engineer, and Roy Grigsby, Axelson Hydraulic Sales. This well makes its allowable of 157 B/D of 32 gravity oil from 9,400 ft. with an Axelson tapered rod string (⅞", ¾", ⅝").

SMALL FRY. The four-foot Hydrax Jr. is a small, economical pumping jack for low-production and stripper wells. It mounts directly to the tubing nipple and requires no foundation. It can be installed within three hours. All controls are at ground level. Rod capacity is 8,000 lbs. First units were put on test, last Spring, and proved so successful that Axelson is now in full scale production with the Hydrax Jr.

AMAZON. Several hundred miles up the Amazon River, deep in the Brazilian jungles is the Novo Olinda Field. An Axelson Long-Stroke Unit is being installed on the first producing well in the region for Petrobras (Petroleo Brasiliero). The unit now pumps 425 B/D from 8,900 feet with an Axelson 1½ bore insert pump and an Axelson three-step sucker rod string.

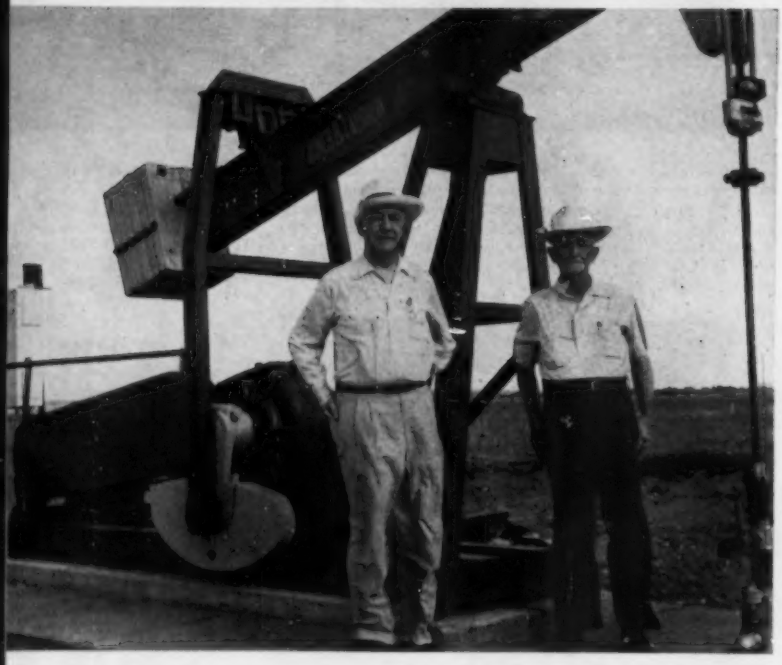




NOTORIOUS. Called the "Double Ram," this unit was specially designed for Union Oil Company. There are 18 of these "Hydrax" units in the Guadalupe Field, California, pumping eight to 14 gravity oil from a depth of 2,800 to 3,100 ft. Pumping conditions here are notoriously rough. Sand cuts run as high as 50%. This unit operates at one stroke per minute (35 sec. on the upstroke, 25 sec. downstroke), lifting 65 B/D with an Axelson 2½" pump.

AXELSON PICTORIAL

HOT ONE. This is Amerada Petroleum Corporation's Mathers A#2, East Cap Rock Field, Lea County, New Mexico. An Axelson 2¾" bore TLE Pump lifts 1,350 B/D (75 bbls. net of 45 gravity oil). Total depth is 11,030 ft.; pump is set at 3,573 ft. Bottom hole temperature of 180° F. does not affect the pump. (l. to r.) Buck Cummings, Farm Boss; Carl West, Pumper; Gene Thomas, Resident Engineer (all of Amerada); Truman Coffee, Axelson Representative.



RETIRING. W. A. Underwood (right), Production Foreman for Cosden Petroleum for 13 years, retired on June 30, 1956, after 50 years of service in the oil fields. He poses for his picture beside the Patterson #1, Howard County, Texas, with Bernard Layman, Jones & Laughlin Field Representative. Axelson Sucker Rods and Plunger Pump are going strong in this well. Depth is 3,100 ft. Production is 100 B/D of 31 gravity crude oil.

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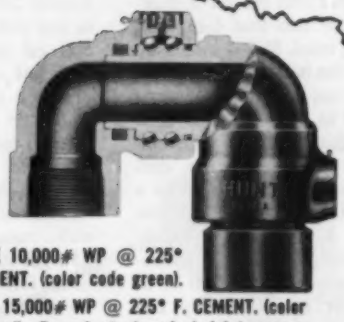

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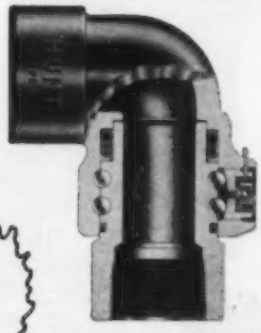

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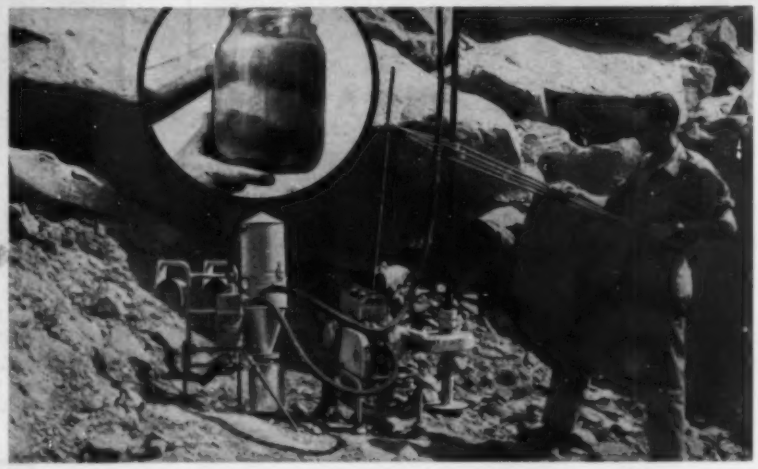
Effect of level change. As an example, assume that a rise of 0.1 ft occurs in a suction pit which is 9 ft by 36 ft. Further assume that the bit is making a 6¾-in. hole and that 6-in. drill collars are being used. If this increased volume entered the hole at a time when the pumps were not operating, it would replace the mud in the lower 630 ft of hole, provided that the 6-in. drill collars extend that far. If the 6-in. drill collars do not extend that far, then a second step will be required on the nomograph to establish the height reached in the second zone. The hydrostatic head pressure due to 630 ft of salt water will be approximately 290 psi less than that of 16½ lb per gal mud. Further instructions on the use of the nomograph are given elsewhere below.

Looking at this 630 ft of salt water another way, it would be reducing the effective mud weight in the hole by more than 3 per cent, if the total head was 10,000 ft of 16½ lb per gal mud. This 3 per cent effective reduction in 16½ lb per gal mud is equivalent to a loss of ½ lb per gal in all the mud in the annulus.

Of course, if this same 0.1 ft rise in the mud pit occurred while the pumps were running it would represent a less serious loss in hydrostatic head pressure. With the same 9-ft by 36-ft suction pit, this added volume is approximately 5.9 bbl or 250 gal. If it occurs in one minute, when the circulation is 500 gal per minute, then there exists 750 gal of this new mixture. This places a majority of the lighter salt water up in the larger annulus zone formed between drill pipe and the hole diameter.

Assuming that the circulation rate has moved all this salt water to the annulus zone around 4-in. drill pipe, this 250 gal still represents about 200 ft of head. For the same 10,000-ft hole with 16½ lb per gal mud, this would be a 1 per cent effective reduction in mud weight, instead of 3 per cent. This would be the same as if all the mud in the hole was reduced in weight by 0.16 lb per gal.

Effect of gas incursion. When high pressure gas is entering the mud stream, an increase in volume will also be reflected in the pit. The volume increase in this case is not so readily converted to an equivalent head loss as in the salt water condition because of the compressibility of gas. A given weight of gas entering at the bottom of the hole will occupy a larger and larger volume as it progresses up the hole because of



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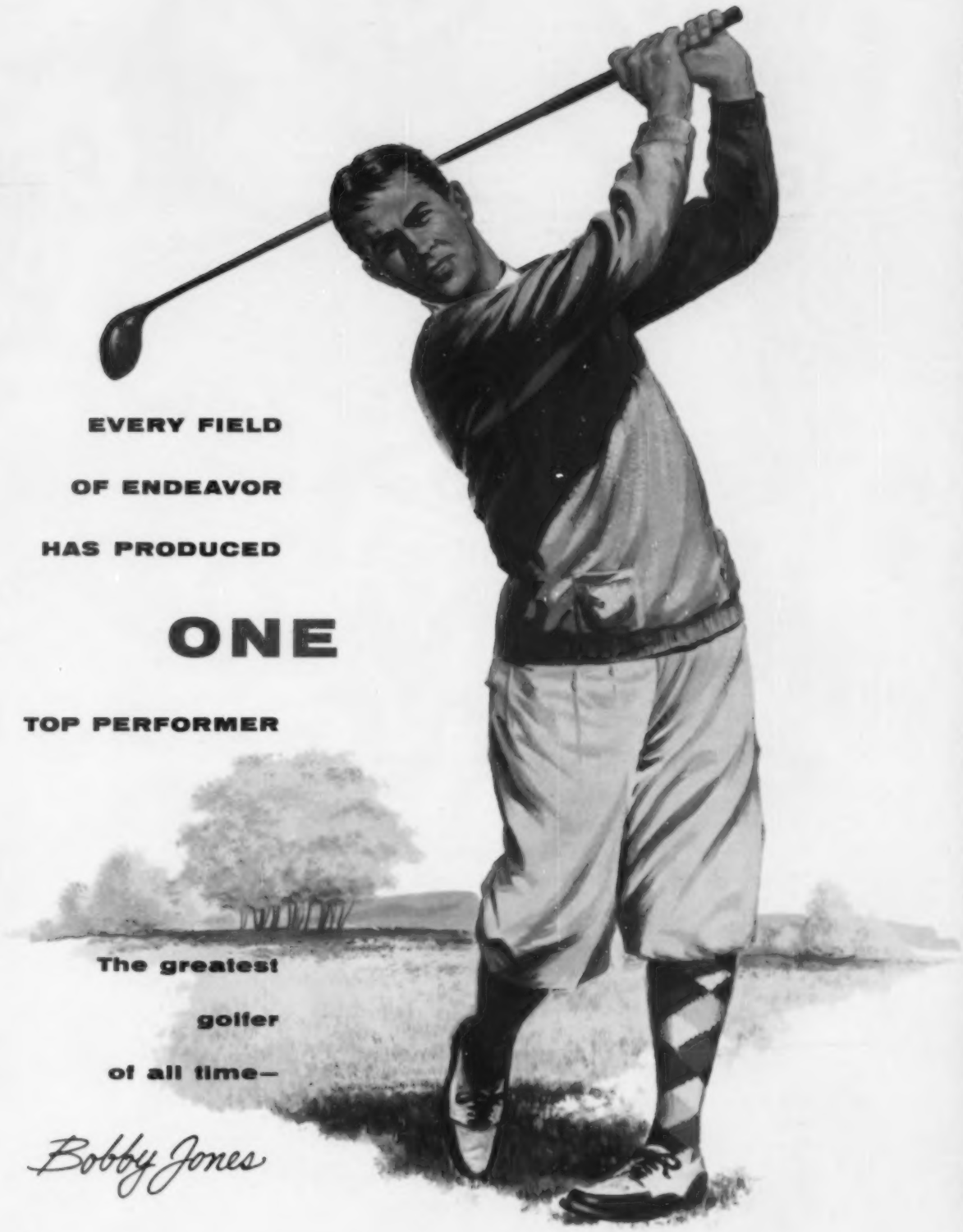

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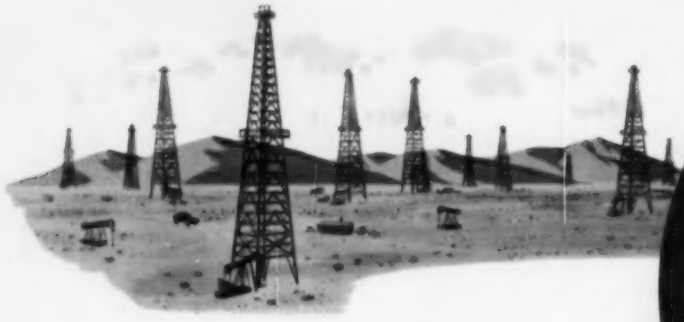

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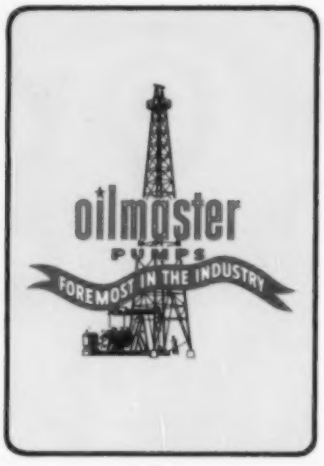

The Author

E. J. Dower joined Warren Automatic Tool Company, Houston, Texas, in 1955 as director of research and development. For five years previous, he was with Southwest Research Institute, San Antonio, Texas, as a senior research engineer, specializing in mechanical engineering and instrumentation in drilling. Before World War II, he attended Texas University and after returning from duty in the European Theater, he completed his BS degree at Trinity University, San Antonio. He is a member of the Instrument Society of America and the Texas Academy of Science. At Warren Automatic Tool, he supervises the design and development of instruments for drilling applications.

the reducing head pressure. This complicates the problem of estimating hydrostatic head pressure loss by the method used above for a salt water incursion. The fact that a given quantity of gas entering at the bottom expands in volume as it rises in the annulus is partly offset by the fact that the annulus area increases by two or more increments up the hole (one where drill collars give way to drill pipe, others where the hole or casing size increase.)

Assuming that the gas incursion (increase in volume) is equally distributed through the mud in the entire length of the annulus by the pump, then the reduction in hydrostatic pressure will be approximately in the proportion of added volume to total annulus volume. This is so because the density of the gas is negligible. A 10,000-ft hole with 8000 ft of 9⅝-in. (8¾-in. ID) casing and 2000 ft of 7⅝-in. (7-in. ID) casing, with 5-in. drill pipe, might have an annulus volume of 2600 cubic ft. Therefore, the previous example of a 0.1 ft pit rise corresponding to 34 cu ft would be equivalent to about 34/2600 or a 1.3 per cent decrease in hydrostatic head and mud weight. This would be equivalent to a .21 lb per gal drop in 16½ lb mud. This is not a large drop in head pressure, but it is an approximation based on the assumption that the 34 cu ft is distributed equally in all the mud in the annulus. The greater the concentration of gas in the smaller annulus area, the greater is the effective head pressure reduction.

If this gas incursion came when the pumps were stopped, so that the lower 300 or 400 ft of 16½ lb per gal mud was entirely replaced, the effective mud weight reduction would be almost .5 lb per gal. Under these circumstances, the incursion would progress immediately to a blowout unless the well was shut in.

The fact that even a small incursion is taking place is evidence the mud weight is marginal for the bottom-hole pressure. Consequently, any further lightening of the annulus mud is very likely to increase the rate of flow. The possibility of this snow-balling effect makes it important to know of the impending action at its very earliest beginnings. After an incursion has continued long enough for gas or salt water cut mud to reach the surface, additional volume gains will not directly effect annulus head pressure until the lighter mixture reaches the suction line and is pumped down the hole.

Loss of circulation. In case of loss of circulation, in the example given of a 9-ft by 36-ft pit area, each 0.1 ft on the recorded chart represents just under 6 bbl. With one half of 1/10 readibility on the chart, the driller can see a loss of as little as 3 bbl. (In a 10-ft by 11-ft suction pit, the driller can read a loss of 1 bbl.)

More important than the actual volume loss is the rate of loss which the driller can observe on the chart. When the rate of loss approaches pump rate, it is approaching complete loss of returns. A loss of 0.1 ft per minute could represent 250 gal per minute with a 9-ft by 36-ft pit. This might be a large percentage of the pump rate, in which case a complete loss of returns might be expected shortly.

Hole fill-up volume. As a by-product of the fractional readability of mud pit level recorder charts, the driller is in a position at all times to check the fill-up volumes required to fill the hole at intervals as the drill string is pulled and to check for flow out of the hole as the string is returned to the hole.

The left side of the "annulus area" line on the nomograph in Fig. 2 has been graduated in pounds per foot weight of pipe or casing being run or pulled. By connecting this value with the length (of pipe being considered) on the equivalent annulus scale, the volume displaced by the pipe may be read on the volume change scale. For example, each 1000 ft of 7⅝-in. casing weighing 30 lb/ft will displace about 62 cu ft or 11 bbl. If the effective pit area is 324 sq ft (as in the previous examples) the nomograph shows that this should give a corresponding rise in pit level of nearly 0.2 ft per 100 ft of casing. This provides a good check to see that a ram effect has not broken down a formation causing it to take mud from the hole.

Significance of pit size. The loss or gain of mud in a particular mud pit is inversely proportional to the pit area. That is, the larger the pit area the smaller will be the level change for a

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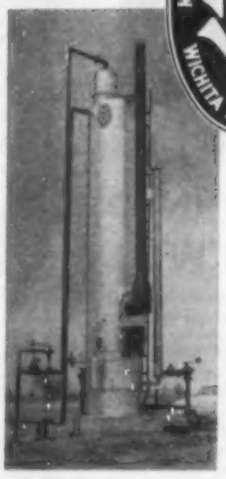

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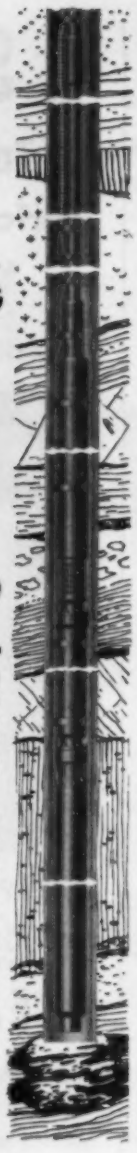

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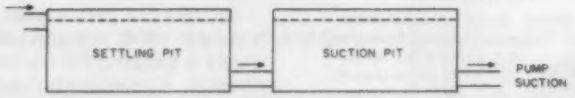

FIG. 3. **Equalizer connects pits** so that both pits change level when mud is gained or lost.

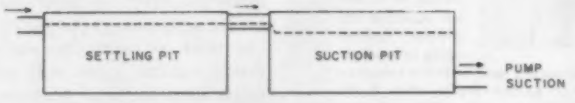

FIG. 4. **Overflow line connected** from settling to suction pit. Gain or loss of mud in the system is reflected only in the suction pit level. Lines between pits in Figs. 3 and 4 should be sufficiently large so that there is only a small relative level change from flowing to static conditions.

given volume. This has led to certain conclusions with respect to surface mud pit arrangements, which are of particular importance in high pressure areas, and/or in areas where loss of circulation is encountered. In either case, the best results are obtained by the use of a relatively small suction pit, whose level is independent of other settling or mixing pits. Such an arrangement is ideal for maximum observation of any change in the total volume of mud in the drilling mud system.

Lines connecting pits. If the suction pit, however large or small, is coupled to other pits by "equalizing" pipes as in Fig. 3, a volume change will be reflected in each pit by an equal level change. In such a case, all of the calculations illustrated previously in this article must take into account the total area of both pits in Fig. 3, and it is much more difficult for the driller to determine, visually or through use of a mud pit level recorder, an important loss or gain in volume in his mud system.

If the pit immediately preceding the suction pit overflows into it as in Fig. 4, any volume change in the whole mud system will be reflected in the level of the suction pit alone. Based on past experience, it is highly recommended that this latter pit arrangement be used in all cases where trouble either with lost circulation or high pressures may reasonably be anticipated.

In either type of flow into the suction pit, the flow course should be large enough to pass the normal pump rate with only an inch or two of head. If the equalizer course between settling pit and suction pit is so small that a 6-in. head is required to accommodate the pump rate, then the suction pit level will rise 3 in. and settling pit will fall 3 in. (if they are of equal area) when the pump stops. Conversely, the suction level will fall 3 in. when pumping is resumed. If the settling pit overflows into the suction through a small gate or weir requiring a 6-in. head for the pump rate flow, a similar situation exists. When these fluctuations are noticed as the pump starts or stops, they do not confuse the driller, but if they are large, somewhat smaller changes will result when the pump rate changes during drilling. If this condition is not avoidable, a pump rate change will cause a variation in recorded pit level.

Pit level important. Because of frequent routine changes in pit level, visual observation of level is not reliable when small changes are important. As the incursion of gas or salt water is often into the smallest annulus section of hole, a small volume of inflow replaces a considerable height of mud. It is the height of mud column which is displaced or lightened rather than mud volume that determines the hydrostatic head pressure change. As the head pressure in turn regulates the inflow, it is very important to know of this condition at its very beginning rather than wait for it to be observed when it has increased in magnitude.

Whether or not the recommended procedure of using a small suction pit is followed it is of utmost importance that the driller, tool pusher, or engineer be fully aware of the bearing the size of his particular suction pit has on the determination of change in hydrostatic head pressure, as calculated from a variation in mud pit level. ★ ★ ★

20 Drilling Hints To Cut Costs

Field-Proven Ideas that will save money, Increase Operating efficiency and provide safer operations

Every drilling rig in operation today is a consolidation of the same necessary and basic components, laid out in a particular fashion according to order of use and area demand — and combining hundreds of individual ideas, attesting to the ingenuity of the contractor and his employees.

Presented on the pages to follow are 20 of these ideas that have proved successful in providing a smoother drilling, moving, completion, or servicing operation, and saving time and money.

Support and Lock for Dog House Window

Where windows fold out on the dog house, a simple device may serve to hold them open. A hinged triangle welded to the frame swings out under the window when it is thrown open, and swings back into the dog house when the window is closed. The window support is made of steel bar stock.

Lock for the window is made by welding a short half-inch nipple to the top of the wall and making a loop of steel of the bottom of the window to match. A pin is then suspended by a chain near the holes so that it is always handy to drop into the holes to secure the window.

Skid Mounted Derrick Floor Speeds Workover Work

Independent Oil Well Service Company of Alvin, Texas, owned by Sam E. Wood, uses a neat arrangement for moving the rig floor, blowout preventers, and rotary table on workover jobs in the Hastings field of Brazoria County. The blowout preventers are hung on the front of the skid mounted derrick floor when in over-the-road position. Rotary table is never separated from the floor. When location is reached, the BOPs are spotted over the wellhead flange; the rig floor is raised and set back against the rig and bolted fast. When it is time to tear down, the reverse procedure is used and as the skid mounted floor is pulled away from the rig, the BOP is hoisted onto the floor and taken in the position — ready for quick application on the next location.

Fuel and Water Tank Moves in One Load

By putting the fuel tank on collapsible legs above the water tank, a compact load can be made for quick moves between locations. When the tanks reach the new location, fuel tank is elevated with the gin-pole truck and the pins placed to keep the legs in position. This permits gravity flow from the fuel tank to all points on the rig.

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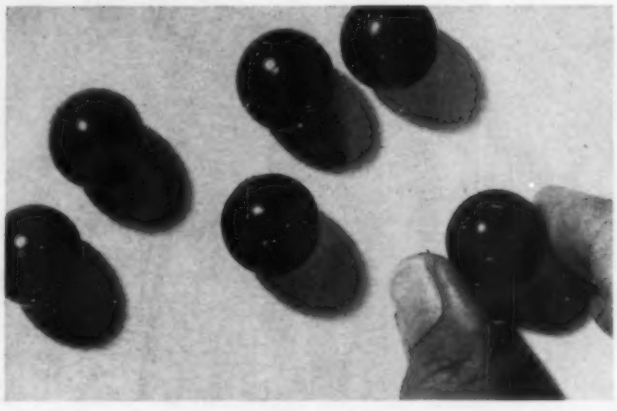
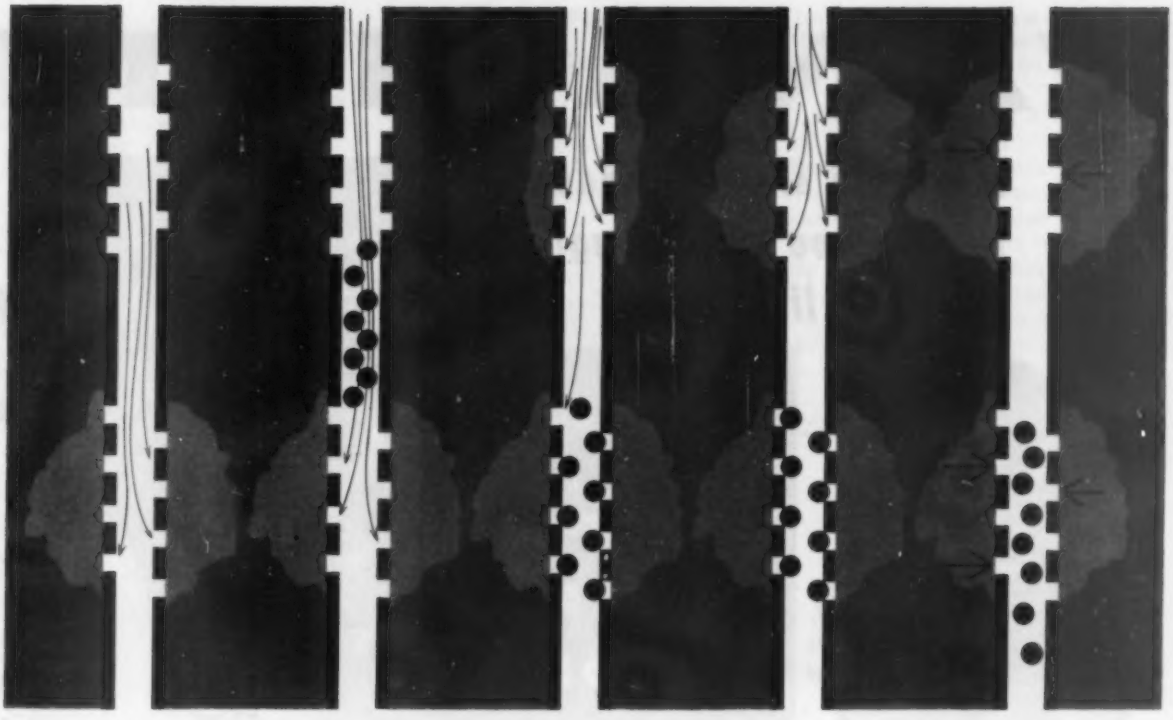


Texas: Odessa, Seagraves, Snyder,



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4 *Upper zone is completely treated while sealers remain in place on lower perforations.*

5 *Pressure is reversed and Ball Sealers drop to bottom of well. Both zones are completely treated.*

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SR-610

Rotary Hose Covering

The rotary hose is usually one of the most easily damaged piece of drilling rig equipment. One contractor provides adequate protection by enclosing the hose in a sheath of heavy ducking. The sheathing is laced around the hose with binders twine. Metal grom-

mets are placed in the material to prevent ripping. The hose shown in the photo is never removed from the rig and nearly all of the surface chafing has been kept from the hose surface. This is the third covering, well worth the time and small expense of covering to save a hose.

Hinged Side Panels Protect Air Compressor

Keeping the air compressor unit out of the weather is easily done by building a frame of 2-in. pipe on top of the skids. A hook in the center for easy loading of the unit makes the unit complete.

A roof is built over the top and hinges are welded on the edges so that panels raised to give maximum ventilation when the unit is running. When it is time to move, the panels can be lowered to protect the unit in transit.

Hinged Cover Allows Rat Hole to be Used also as Mouse Hole

Drillers of shallow wells can make use of a Freeport Sulphur Company idea used in digging sulfur wells in Texas and Louisiana. A rat hole with a hinged lid doubles as a mouse hole by holding a joint of drill pipe at the tool joint.

When the kelly joint is up in the rig, the next joint of drill pipe is brought in with a cat line as usual. Instead of allowing it to remain on the ramp or digging a separate hole, the hinged lid is placed on the rat hole casing and the next joint positioned. The cover holds the joint so that the kelly can be swung over and made up into the next joint. This can be a real time saver while making connections.

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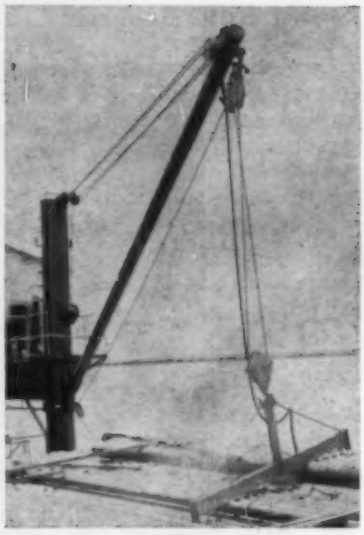
Cantilever Post Serves As Compressed Air Chamber

On Golden Meadow Well Service's rig working south of New Orleans, a joint of 16-in. pipe is used as the support for the cantilever boom that is used to unload and load barges. This provides a strong support for the boomer and also doubles as a separate tank for compressed air.

The unit was made by first rigging the boomer and then welding the top end of the 16-in. pipe closed, installing a pressure gage and welding on the air connection. A ladder is placed on the side to make it easy to service the sheave on the top of the post. This also provides a measure of safety as any cracks that may develop in the post due to fatigue or corrosion would be immediately noticeable.



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PAYNE PUMP ACCUMULATOR UNITS DESIGNED FOR OPERATION OF ALL TYPES AND MAKES OF HYDRAULIC BLOWOUT PREVENTERS

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Payne Pump Accumulator Units are available with Pumps to operate on air, gas, steam, or electricity. All the Pumps have Automatic Pressure Control Switches to keep Accumulators charged automatically. Units may be purchased with 1 or 2 Two-Stage Pumps or from 1 to 5 Single-Stage Pumps. Pumps have By-pass Valve installed to by-pass automatic pressure setting — to produce higher pressures when needed.

Payne Pump Accumulator Units are available with Fluid Control Valves mounted on the operating unit (as shown) or mounted on separate floor stand. Payne Remote Controls are available for operation with air, fluid, or electricity.

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Payne RAM Series Pumps are single or two-stage, double-acting, simplex pumps which operate on air, gas, or steam. There are three series of this pump, the RAM 2000, 5000, and 10,000 Series. Any pump can be furnished with several standard sizes of Fluid Cylinders and Boosters for a wide range of volumes and pressures.

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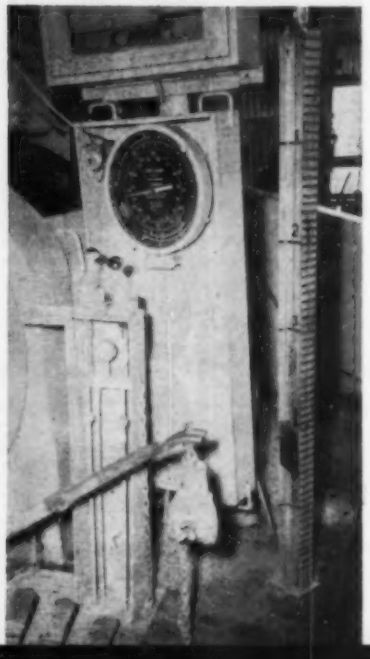
A simple arrangement with a float, wire line, and weight can be easily rigged up to show the driller the level in the suction pit the same as the weight on the bit. The float is placed inside a piece of pipe in the suction pit and then the wire is strung with pulleys beneath the derrick floor so that it comes up through the derrick floor in front of the driller. It is then easy to set up an I-beam so that the wire can be strung over a pulley on top and attached to a weight on the I-beam. A scale is then painted on the beam to correspond with the level of the mud in the suction pit and the driller can tell within a tenth of a foot the exact level in the pit.



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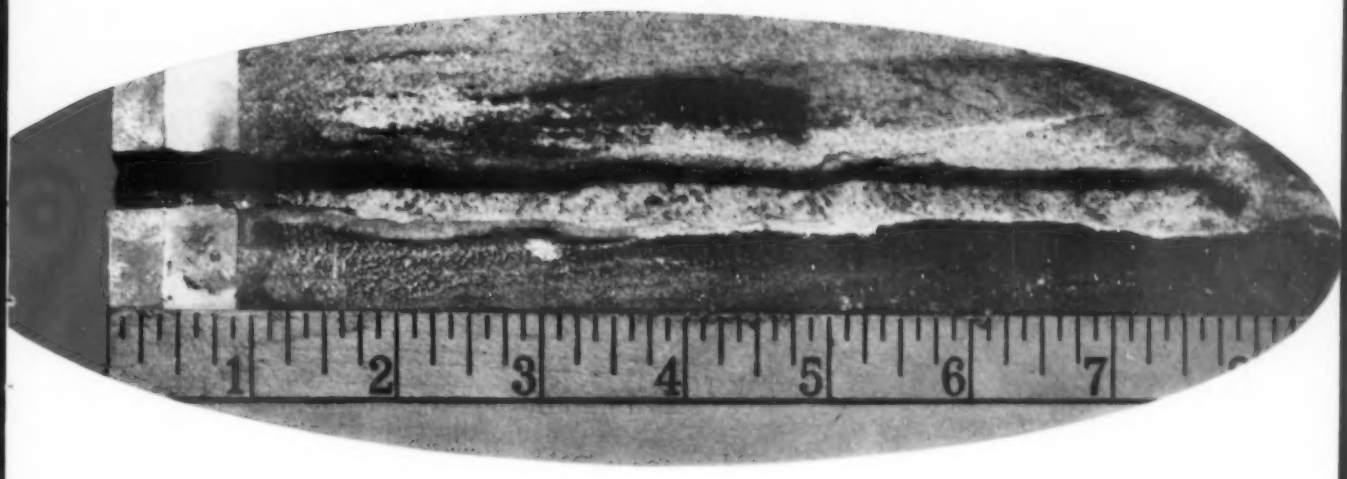

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PENETRATION AND HOLE SIZE ARE NOT SACRIFICED

Perforating characteristics of the new charge maintain the high standards set by the former Schlumberger charges. This is confirmed by the target above.

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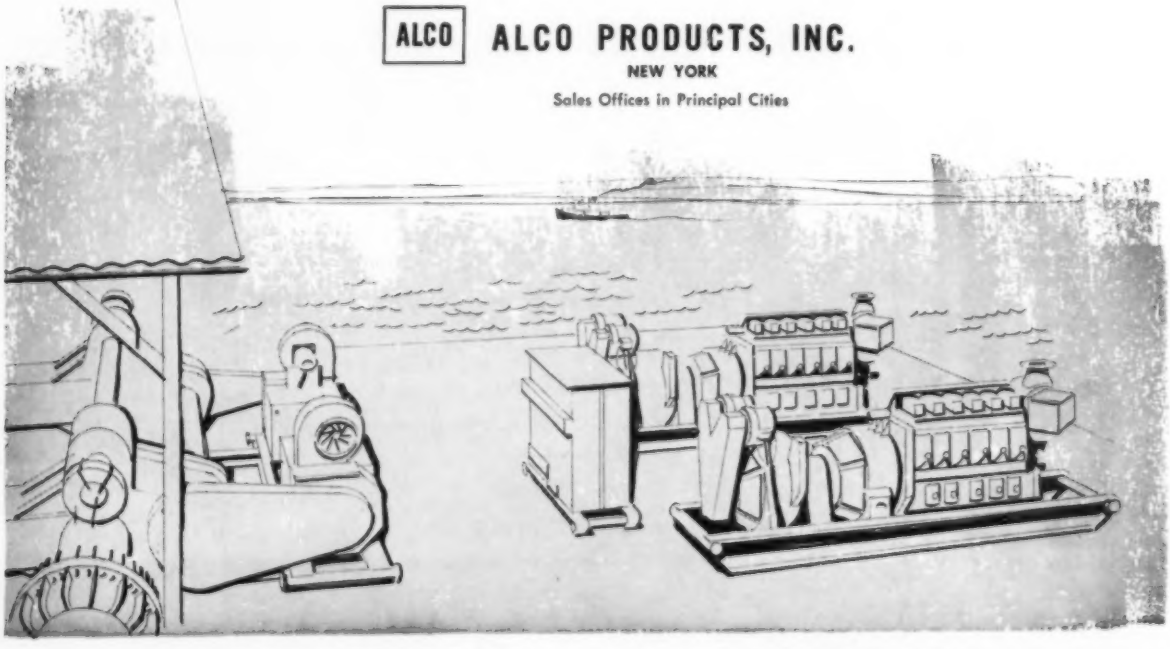

Pipe Trailer Used to Move Bailers and Stems

Ed Hess of Muenster, Texas, rigged this trailer to move his bailers and stems for his shallow drilling rig in Cooke County. It was made by welding king pins on the front axle of a junked car and making a frame of 2-in. pipe to lay the equipment. The tongue is made from 2½-in. drill pipe and another 2-in. frame is mounted on the front. Trailer is hitched to the back bumper of Hess's pickup truck whenever it is necessary to move a bailer or stem.

Compact Unit Takes Up Slack in Well Logging Unit

When it is desired to have a drilling rate chart in the mud logging truck, some system to take up slack is highly advantageous. A simple rig running over the top of the derrick can be made by using a heavy weight and block and tackle in reverse. The line from the derrick is wound on the small shaft, shown at the top of the photo, the line from the large drum feeds the block and tackle. Using five lines in the block and tackle arrangement and the large winding drum, sufficient slack is taken up on the rig line to allow the traveling blocks to traverse the complete length of the derrick. The derrick line operates a stylus on a chart showing the height of the blocks at all times, shows the drilling rate, as well as indicating round trips, connections of new joints, etc.

Neat Hat Racks Made From Welding Rods

The hard hats around the rig are a nuisance if not kept in place; sometimes valuable time is lost while the roughneck hunts his hat. One company welder took heavy welding rod material and made a set of racks on the dog house ceiling. Ends of the rod were tacked to back of the building and brought out about two feet, bent, turned up and then welded into the ceiling of the dog house.

Door of Mud House Protects Hopper

Drilling mud additives can be kept out of the weather right up to the moment that they are dumped into the mixing hopper by simply building the porch as shown. Pronto Drilling Company of San Antonio placed a door on the side of the mud house with overhead hinges. After the house is spotted, the hopper is set beneath the door so that mud can be added to the drilling fluid in the most inclement weather. Even the control valves on the hopper are placed beneath the roof-door so that they can be operated without the mud man getting in the rain.

Sliding Ramp for Offshore Work

A novel ramp arrangement is being used to service the rigs in the Plumb Bob and nearby fields in South Louisiana. The ramp, on Texas Company's Henderson landing in St. Martin Parish, six miles east of Breaux Bridge, is arranged so that as the water level raises, it is pulled up an incline — always providing a level run for the trucks driving onto the barges. This allows mud and supplies to be unloaded at the rig just as if it were a land rig.

The sliding ramp has hinged skids that can be lowered to the barge side and trucks driven off at an angle. Two cables run along each side of the ramp and are attached to the sliding ramp. These cables are moved by winches to pull the horizontal part up and down to adjust for water level. The ramp adjusts to changes of water level up to 6 ft.

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Through the Hewitt-Robins *5-for-1 Hose Program*, tool pushers and drilling contractors can save money and increase the mileage on Rotary Drilling Hose. This unique service consists of three easy steps. Here's how it works—

STEP 1 . . . . Purchase a standard 55-foot length of Hewitt-Robins Rotary Drilling Hose fitted with Stratoline Couplings.

STEP 2 . . . . After normal wear occurs, or if the hose is damaged in service, send the used hose to our factory repair service in Houston. If more than a 45-foot length of undamaged hose remains, we will reset the couplings, test to the original recommended pressure and return the shortened length for your use in drilling additional feet of hole.

STEP 3 . . . . When this shortened length wears out, additional salvage is possible. Once again return the hose to Hewitt-Robins for conversion into as many as three 12' to 15' lengths of vibrator hose.

Thus you actually can get 5 hoses for the purchase of one—with only a nominal charge for repair service. Anyway you figure it, this makes Hewitt-Robins Rotary Drilling Hose your most economical buy—*giving you more hose service for less hose dollars.*

For information about Hewitt-Robins Rotary Hose Repair Service, write, wire or call our District Office at 5711 Navigation Boulevard, Houston 11, Texas, WAlnut 6-3193.

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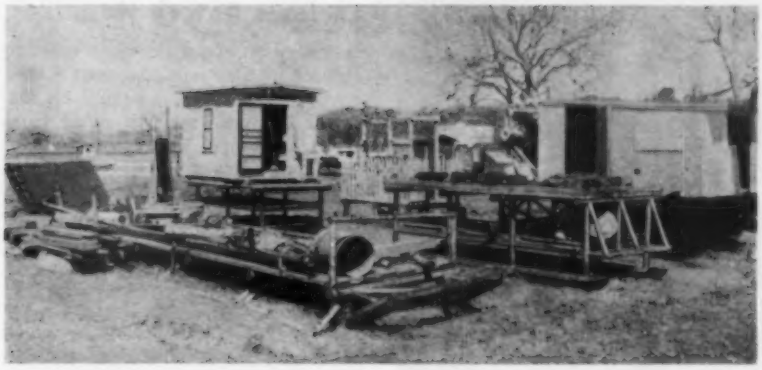
Complete Skid Mounted Rig



When one company had several wells to drill in a swampy area, all equipment was put on skids and moved with tractors. The catwalk is shown in the foreground with loose materials piled on top while the rig is temporarily stacked. To the right is a portion of the rig floor and to the right of that is the drawworks and rotary table. In the background is the dog house — also mounted on skids.

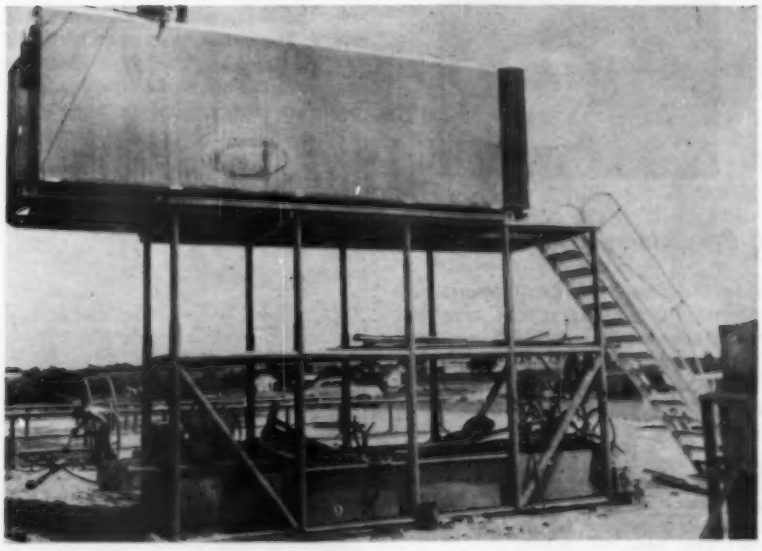
When it is time to move, the drawworks and rotary are skidded into position and then each of the pieces moved in separate loads. The derrick, not shown, is also skid mounted.

Collapsible Ramp Facilitates Tractor Loading

A rack to facilitate tractor loading may be made by extending the bed of the trailer so that the extension will collapse into the frame when in the over-the-road position. The movable part is made so that it can be handled by one man. The front of the movable part is hooked over a beam at the lower end of the I beam side pieces, when the lower end is on the ground. When it is collapsed, a runner across the bottom hooks securely into the same beam so that it cannot be jarred loose.

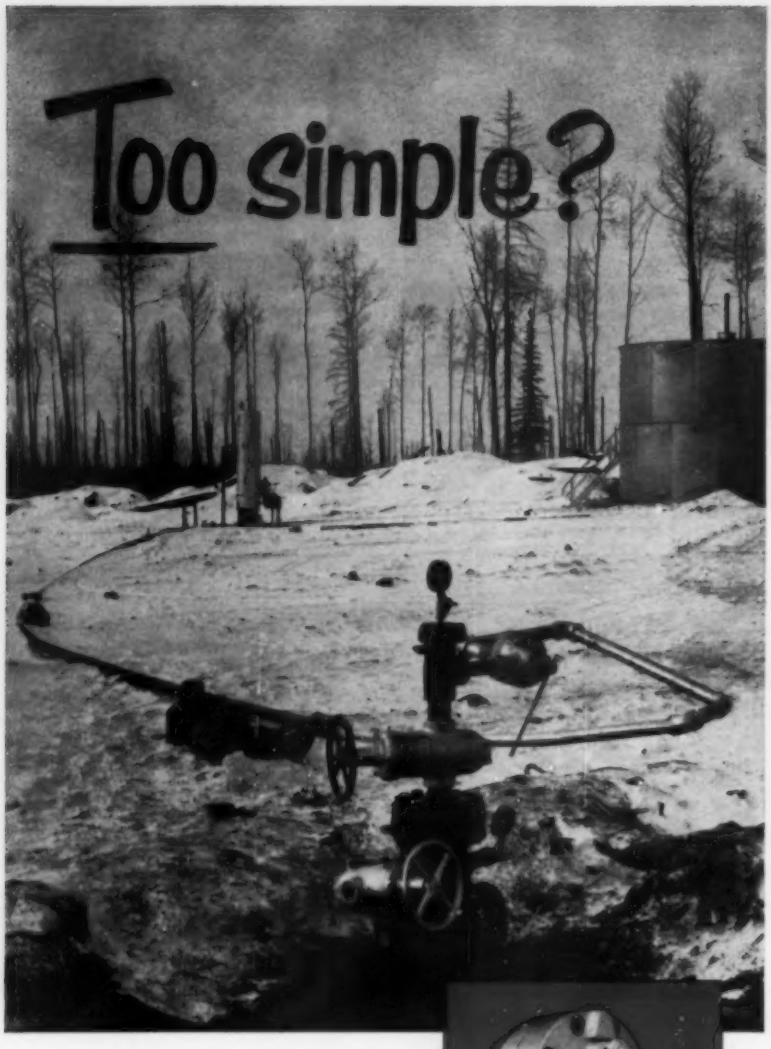
The entire assembly is welded securely to the back of the trailer and taillights are placed inside guards on the back corners. When it is necessary to load or unload the tractor, the ramp is pulled out and the end laid on the ground to give a firm support.

Adjustable Support Holds Dog House At Rig Floor Level



Where rig floors must be several feet above ground level to make room for the blowout preventers, a collapsible support may be built to adjust the house to the rig floor level. When the dog house is unloaded from the supports onto a truck, the supports are telescoped down inside the frame so that it can easily be moved.

The frame is made from old drill pipe and has a bin built into the bottom to contain small tools and fittings. On top of these, odd pieces of pipe may be racked for use around the rig. When the rig is being moved, the entire compartment is filled with material to be used around the rig. After the frame is spotted at the next location, the top part is telescoped and the dog house dragged off the truck and skidded to the rig floor by means of a derrick line.



In the northern frontier of Alberta, the two-valve, uncomplicated Christmas tree of the Union Oil Company well "Red Earth 12-17" loafs along at 200 BPD, reduced from a tested 960 BPD, through a

WILLIS
Rotary Adjustable Choke

Adjustable Flow Control with Pre-determined Accuracy

Willis Rotary Adjustable Choke provides 6 different size choke inserts which are individually positioned in the line of flow by a fractional turn of the orifice-carrying disc . . . while under constant flow and high pressure. Simplicity of this uncomplicated Christmas tree (note deletion of wing valve) is accomplished by using a blank orifice in one of the 6 positions of the Willis Rotary Choke. Also without closing the master valve shut-in of the well can be effected.

WILLIS OIL TOOL COMPANY
3440 Pine Avenue, Long Beach, California
Houston: P. O. Box 12164 Park Place Station; **Odessa:** P. O. Box 412;
Canada: Precision Oilfield Service, Ltd., Edmonton, Alberta

Pipe Frame Completely Encloses Rotary Hose

Rotary hoses are damaged more in moving than in actual service. A simple protective frame to completely surround the hose may be made from scrap 2 in. pipe. Two pieces of 2-in. line pipe were bent into a 6-ft circle and 18-in. braces were welded between them. One side of the circle is completely enclosed by two cross members of the same material.

The hub is formed by four pieces of pipe 18-in. apart inside the circles. On the one side of this a plate is welded with a ½-in. bolt welded in the center. This bolt is made to match a hole in the center of two crossed 2-in. pipe. This clamps over the open end of the compartment after the hose has been wound into place.

Metal Box Over Shear Relief Valve Acts as Safety Shield

On barge rigs where flying nails may become a hazard, a metal box slipped over the shear relief valve may prove useful. The box is constructed with half of the bottom open to allow space for the outlet line. In the lower corner, holes are burned with a welding torch so that a pin can be slipped through to hold the box level.

The discharge from the relief valve feeds back into the suction without a fluid loss when the valve pops . . . and there is no mess to clean up inside the mud pump room.

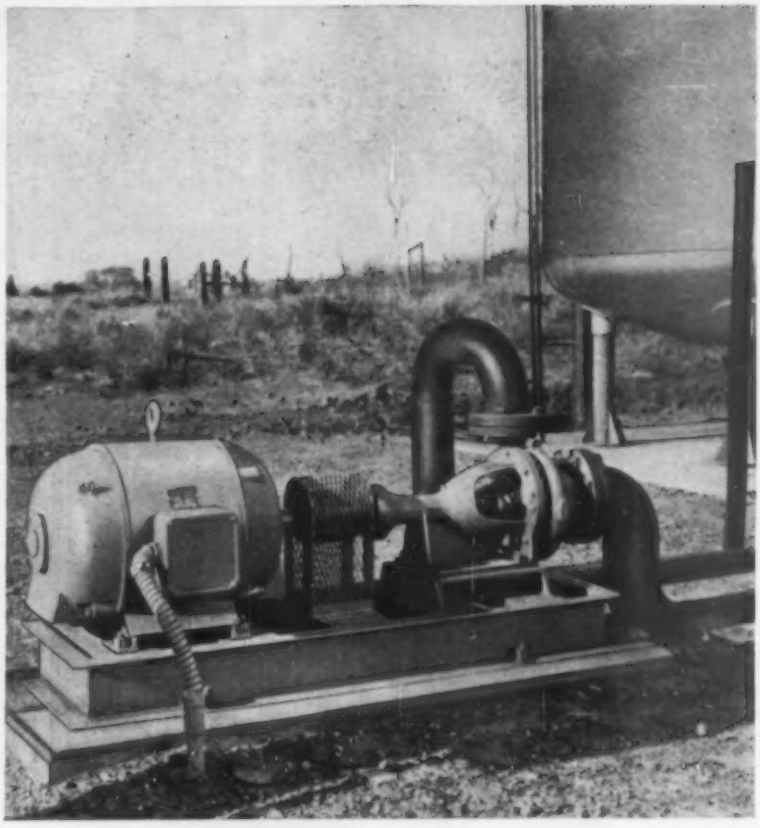
Drum Mounted on Workover Rig Keeps Brakes Cool

On workover rigs where a lot of bailing or swabbing is being done, the brake blocks can be kept from burning by keeping a drum of water mounted at a convenient height above the drawworks. A ½-in. line is run to a point above the brake drum and a valve on the bottom of the drum opened slightly. This allows water to trickle onto the brake drum, keeping it cool throughout the operation.

Boomer Attached to Front Of Truck Aids Rigging Up

One contractor who used a truck with a front mounted winch found it very convenient to place gin-poles on the front of the truck to aid in rigging up. The drive has full visibility and with the aid of a swamper can snatch the material from the bins and place it where it belong on the rig.

A heavy piece of drill pipe is used for the front bumper and the gin-poles attached to the sides. In order to make a firm support, the upper brace is hooked to the top of the headache bar behind the truck cab. This member may be telescoped to adjust for heavy lifts near the truck or lighter lifts at a greater distance.



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- *Delivery of treated water*

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P-23

EXPLORATION ACTIVITIES

PANAMA

★ Cataract Mining Corporation of New York has acquired oil and gas concessions in excess of 2,000,000 acres, to speed up the exploitation of Panama's resources. This is the first major development in Central America since Union Oil of California brought in its first major well in adjoining Costa Rica recently and began its drilling in Panama. The larger part of Cataract's concession is located in the province of Chiriqui alongside the Costa Rican border and is part of the newly discovered giant oil field where Union Oil of California brought in its discovery well. Cataract will start drilling next month. It is understood that at least 15 major oil companies are presently seeking or already have acquired concessions.

COSTA RICA

★ Union Oil Company of California has made an oil discovery of importance in Limon Province, the well is flowing at the estimated rate of 1000 bbl a day. This is the first commercial oil discovery in Costa Rica where Union Oil has a 3,500,000 acre concession adjoining a concession of an additional 350,000 acres directly across the border in Panama. On the first of two formation tests, Union's discovery well, Cocoles No. 2, flowed 46 deg clean oil at the rate of between 200 and 500 bbl a day; on the second test the well flowed at the rate of 1000 bbl a day with high pressures. The company has run casing to complete the well which reached a total depth of 4950 ft. Cocoles No. 2 was drilled after Cocoles No. 1 showed traces of oil. The well is located about 1 km from the northeast border of Panama and is about 25 km by road from the Caribbean coast. Drilling in the Panama concession is being undertaken immediately.

TEXAS

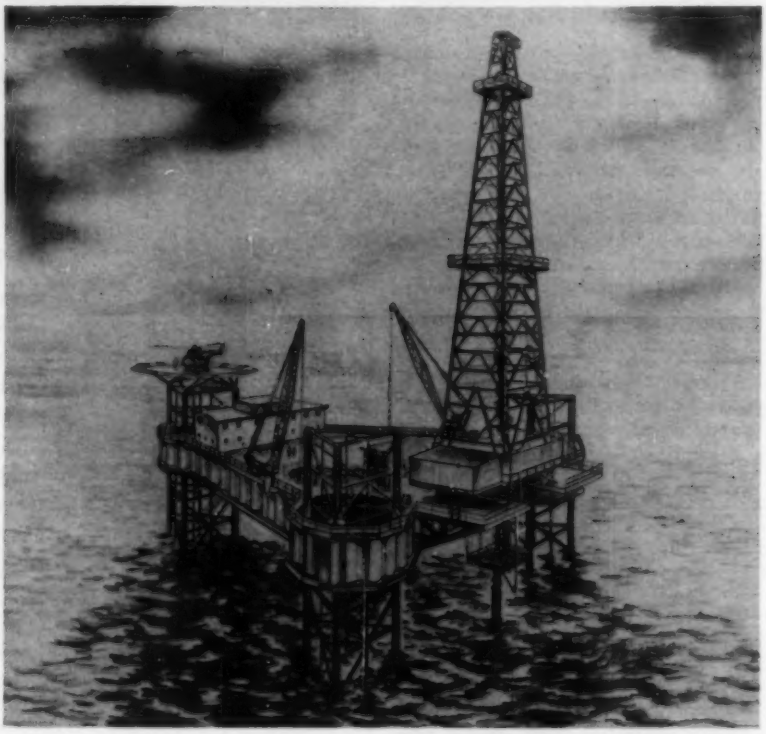
★ A significant gas-distillate discovery well three miles west of Portland in San Patricio County, Texas, has been completed by the Marine Gathering Company, wholly owned subsidiary of Commonwealth Oil Company of Houston. The well, the No. 1 Eva Anderson, is producing in Frio sands at depths between 9570 and 9950 ft. The electrical log, core analysis and other tests indicate a net effective sand thickness of 105 ft. Total depth is 10,510 ft. Well, completed through perforation at 9923-38 ft, flowed at the rate of 3,100,000 cu ft of gas per day on a ½-in. choke with tubing pressure of 3100 psi and bottom hole shut-in pressures of 5340 psi. Distillate content was estimated at 60 bbl per million cubic feet of gas. The company controls 870 acres around the discovery and plans to drill additional wells immediately.

★ Completion tests have been run on the South Borden County discovery by J. D. Wrather, Jr., and Republic Natural Gas Company. The well is the No. 2-16 T. J. Good, finaled in the Fusselman for a daily potential of 205 bbl of 41 deg oil, flowing through an 18/64-in. choke. Production is from interval at 9805-15 ft, washed before test with 250 gal of mud acid. Gas-oil ratio was 821 to 1. The field opener is 2½ miles northeast of Vealmoor and 1½ miles north of the Vealmoor (Canyon Reef) field.

★ Advance Petroleum Company, Dallas, has completed its No. 1 William Howard, Southwest Glasscock County wildcat, as a producer from the lower Spraberry sand. Daily flowing potential has been set at 435.5 bbl of oil. The flow is through a ½-in. choke. Production is from 7350-57 ft. Zone has been fractured. Well is 16 miles southwest of Garden City, 2 miles east of production from the upper Spraberry and 1½ miles south of a lone lower Spraberry well.

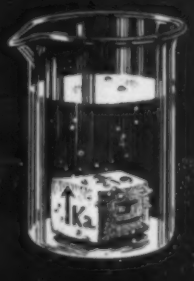
★ An important Edwards lime gas-condensate discovery has been completed by Lone Star Producing Company in Atascosa County, in the southern part of the state. The well, the No. 1 L. T. Urbanczyk, on daily potential test (natural) yielded 36,000,000 cu ft of gas and 23.75 bbl of 51.6 deg condensate. Shut-in reserve pressure was 5177 psi and tubing pressure was 3986 psi. Productive section was from 10,420 to 10,430 ft. Production possibilities were also indicated from zones at 10,790-816 ft and 10,824-50 ft. Discovery was on a 3500-acre block in the Fashing area.

★ Five miles southwest of Gomez, in Terry County, The Texas Company has brought in a new Devonian discovery flowing 423 bbl of 35.7 deg oil on a



Artist's concept of a $3,500,00 portable offshore platform now under construction for Zapata Offshore Company. In operation, the 8,000,000 lb unit can lower its 145-ft legs to the bottom of the Gulf and, within a 2-hour period, will have elevated its deck to the height of a 10-story building above the ocean floor. R. G. LeTourneau, Inc., the builder, expects to deliver the platform by February 1.

today's special . . .



INFORMATION ON THE ROCKS

Have you ever wondered what happens to the permeability plugs cut from your core samples during conventional core analysis tests?

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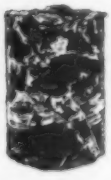
Just as Core Lab carefully maintains confidential files on every Core Analysis Report made during the past twenty years, this "perm plug library" is symbolic of our uncompromising attitude toward the value of every thread of *measured* reservoir data.

For example, it is not uncommon for a client to request Core Lab's Special Core Analysis Studies Group to use his perm plugs in measurements for broadening the scope of original basic information — i.e., to evaluate water flood possibilities, to determine the effects of extraneous water on the flowability of a particular formation, to accurately measure connate water values, etc.

From the day you receive virgin formation data, until a pool is depleted, you can enjoy the advantages of Core Lab's stable, business-like methods of professional reservoir engineering.



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14 hour test. Wildcat flowed from perforations at 12,763-98 ft. Choke size was not reported. Well is the No. 1 Allan C. Black, bottomed at 12,801 ft.

CALIFORNIA

★ Standard Oil of California has a potential extender to the Oxnard field in Ventura County. The stepout is the Diedrich Community No. 1 located about one mile northeast of the Maulhardt well in the field proper. On production test, the well flowed at a rate of 960 bbl a day of 27 deg oil from the Sespe zone at 6220-360 ft.

★ The Texas Company has been credited with a new pool discovery in the Placentia area of Orange County. Strike is the No. 1 Dowling, drilled to a total depth of 8115 ft. Well was completed on pump and is now yielding 120 bbl per day of 17.1 deg oil, 10 per cent water cut, from plugged depth of 8074 ft. Contractor for the hole was Graham & Klassen Drilling Company.

★ A northwesterly field extension has been marked in the Bridge area of the South Mountain field by a Texas Company-Union of California joint venture. The Texas Company, acting as operator, completed the Stine No. 1 from the Pliocene, perforating at an interval at 7170-941 ft. Initial production was 1223 bbl daily of 31.3 deg oil through a 22/64-in. choke.

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NEW ZEALAND

★ The British Petroleum Company, through BP Exploration Company, has concluded arrangements with Todd Brothers of New Zealand for a joint oil exploration program on the east coast of the North Island of New Zealand where both BP and Todds hold prospecting licenses. The initial cost, which is expected to be about $1,400,000, will be provided by BP who will also provide management and technical staff. Work is expected to begin soon.

CANADA

★ Cities Service's Cardium discovery 12 miles east of the Pembina field and fifty miles southwest of Edmonton flowed at a daily rate of 708 bbl during an 8.5-hour period the last day in a five-day test. The Alberta Province well flowed a total of 1251 bbl during the five-day test and is now shut-in for storage. The flow was from the Cardium sandstone through perforations between 4332-4340 and 4296-4325 ft. Cities Service is scheduled to drill another well on the 6000 acres it has in the immediate vicinity of the discovery.

★ Honolulu Oil Corporation and associates have completed their Paddle River No. 16-17 well as a Mississippian oil discovery. The rank wildcat is 40 miles north of Alberta's Pembina field. The well flowed 288 bbl of 18 deg oil daily on initial potential test from perforations at 5196 to 5210 ft. Potential was based on a three-hour test through 16/64-in. choke.

VENEZUELA

★ Immediate development leading to drilling operations in the Lake Maracaibo area has been planned on recently granted government concessions to exploration subsidiaries of Signal Oil and Gas, Hancock, Pure, and Ohio Standard oil companies. Signal's subsidiary, Signal Exploration Company, is acting as operator for the group. The four companies have been granted a parcel containing over 27,000 acres in the lake, immediately adjacent to producing properties of other operating companies. Only preparation of certain documents and formal issuance are needed to begin drilling operations, say company officials.

WYOMING

★ New pay discovery has been tested by Sinclair Oil & Gas Company in the East Slat Creek field, Natrona County. The company's No. 8 Government, first to test below the Cretaceous in the field, flowed 216 bbl of oil per hour on drillstem test of the Tensleep (Pennsylvanian) at a depth of 7551-81 ft. Flow was tested 34 minutes after tool was

The case of the traveling triplex pump

This truck-mounted National triplex pump is paying off for one of our customers in Kansas. Used for sand frac service and washing wells on an extensive waterflood property, it's the first of three such portable F-90 pumps to be put into action.

And the action is fast. Like a National portable rig, this pump can be quickly moved between well sites. Its mobility and its dependable operation insure economical servicing.

This pump has been used on wells ranging from 500 to 1,000 feet, and at 1400 to 2,000 psi formation breakdown pressures. The injection rate is 6½ barrels per minute at 750 to 1,000 psi, using sand and crude oil as injection material. For well washing, water is circulated at a 3 to 4 barrel per minute rate, at 1,000 psi for 1 to 3 hours. So far, this "traveling pump" has completed service on more than 40 wells—and the customer is very satisfied with its dependable operation.

On the next two pages, you'll find the reasons why National Triplex Pumps perform profitably *wherever* you put them to work. In this respect, they are typical of the complete line of quality drilling and production equipment bearing the National Blue label. You can get full information—along with alert supply service—on this line at the National Supply Store in your area.

THE
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NATIONAL TRIPLEX PUMPS ARE PROFITABLE

Waterflooding is just one of the many jobs you can do profitably with National Triplex Pumps. They're equally effective for salt water disposal, high pressure testing, formation fracturing and acidizing, and as power-oil sources for sub-surface hydraulic systems. And wherever you put them to work, they deliver dependably—with little or no service downtime.

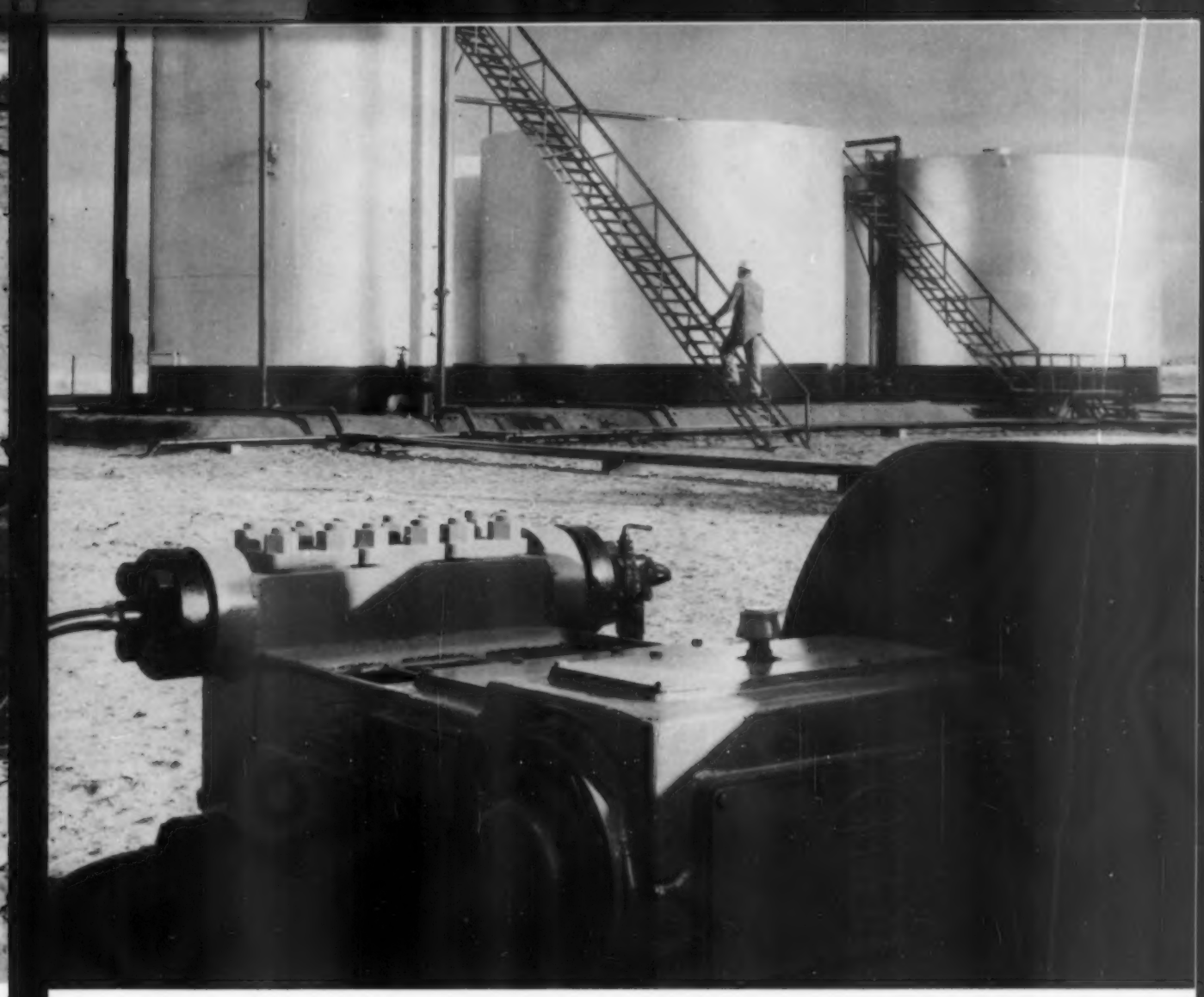
Simplified, rugged construction insures their sound performance, and their compact design requires a minimum of space. National Triplex Pumps have heavy-duty housings and frames, long-life bearings, stainless steel valves, National's time-proven lubrication systems, and a minimum of wearing parts.

Plungers, fluid ends and stuffing boxes are interchangeable, thus providing the flexibility to meet varying pressure and volume needs. They are also available for either corrosive or non-corrosive service.

You'll find, too, that National Triplex Pumps are easy to install and maintain. They're adaptable to V-belt or direct drive, and are easily fitted to unitized skid mounting for complete portability. For minimum maintenance and speed in plunger size changeover, these pumps have easily removable cartridge-type stuffing boxes.*

These are just a few of the reasons why National Triplex Pumps pay dividends on many oilfield and petrochemical pumping jobs. The National Supply field representative in your area will be glad to give you more information. Ask him soon.

*Patent Pending



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Check their performance...

Model Number	Rated Discharge Pressure Range*	Barrels Per Day Range*
F-15-L (Low Pressure)	500 to 825 psi	430 to 1770
F-15-M (High Pressure)	1120 to 2520 psi	140 to 785
F-60-L (Low Pressure)	835 to 1575 psi	1120 to 4230
F-90-L (Low Pressure)	685 to 1345 psi	1955 to 7715
F-60-S (High Pressure)	1575 to 4975 psi	355 to 2240
F-90-S (High Pressure)	1660 to 5375 psi	480 to 3190

*Based upon standard pump speeds and rated HP output

THE
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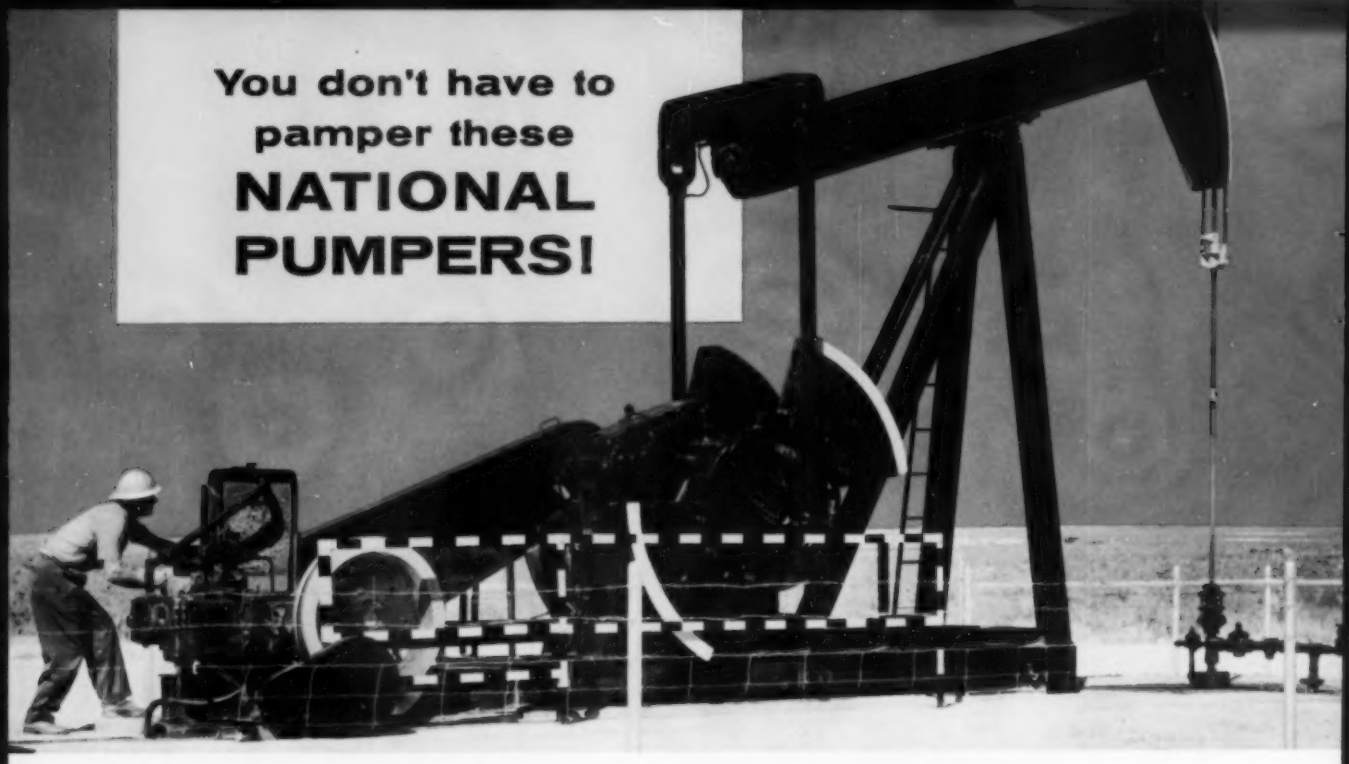
SPANG STEEL PIPE AND ELECTRICAL CONDUIT

On the next page: more National equipment for profitable production!



You don't have to pamper these NATIONAL PUMPERS!

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- **Pitman assembly features easy maintenance, fast assembly.**
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Get the complete facts on National Pumpers today. For the full story on the high performance and low operating costs they offer, see the National Supply Store men or representatives in your area soon. New bulletins describing these quality pumping units are available.

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This National unit uses either formation gas or injected gas pressure for operation. Under the proper conditions, this method of operation can be exceedingly economical.

NATIONAL Wellhead Equipment

Interchangeable units provide many combinations to meet your specific needs in size, capacity and type. Ease of assembly and pre-tested safety are two major features of this equipment.

opened. Flowing pressure was 900-2900 psi. Sinclair cored almost all of the Tensleep, topped at 7386 ft, to a depth below 7581 ft. Operator indicated that most of the formation was apparently productive, as indicated by successful drillstem tests at 7383-426 ft, at 7426-66 ft and at 7514-51 ft. The new pay discovery represents a renewal of exploratory interest in the basin area immediately east of the production on the basin's flank.

LOUISIANA

★ A new producing sand for the Eola area of Avoylles Parish has been discovered by Gulf Coast Leaseholds' No. 1 Levi O. Campbell. On production test, the wildcat tested 425 bbl of 34.1 deg oil a day, through a ¼-in. choke, from the Cook Mountain sand. Discovery, ¾ mile of nearest production in the Dave Hays field, is flowing from perforations at 7155-64 ft. Well was drilled to a total depth of 8764 ft and plugged back to 7164 ft.

★ In Jefferson Parish, Union Oil and Gas Corporation and Sun Oil Company have jointly completed a significant extension to the Lake Arthur field. The project, the No. 1 Lanthier, was drilled to a total depth of 16,287 ft, was completed at 15,756-86 ft. Well flowed 232 bbl of 43.2 deg oil daily. Gas-oil ratio was 3400-1 and tubing pressure was gaged at 7100 psi. Flow was through a 6/64-in. choke. The well is the deepest completion in the field and extends production more than one-half mile to the south.

KUWAIT

★ Discovery of oil on a new structure some 60 miles north of the present producing area was reported in the press in February 1956 following the drilling of a test well designated Raudhatain No. 1. A second test at a location 1.8 miles southeast of Raudhatain No. 1 was spudded on December 12, 1955 as part of an exploratory program to investigate the extent of this new field and the commercial value of this discovery. This second well designated Raudhatain No. 2 was drilled to a total depth of 9695 ft. A smaller rig will be moved in at a later date to complete the testing program. The drilling rig was moved from Raudhatain No. 2 to a location approximately 8 miles to the east-southeast known as Sabriya No. 1 and is now drilling at a depth of 1700 ft. An additional exploratory well is drilling at a location approximately 6 miles northwest of Bahrah No. 1, the first test well in the state of Kuwait which was drilled in 1936 and resulted in a dry hole.

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What's doing in DRILLING

★ **Man-made island,** being constructed by Richfield Oil Company, will serve as the apex for drilling 70 wells on the company's 1175 acre offshore lease near Rincon, California. The island is being built in 45 ft of water more than half a mile from shore. Total area at the water line is about three acres, although the working area will be only one acre, since palm trees and shrubbery will surround operations — giving the effect of a natural island from the shore. The island, costing between $2,000,000 and $3,000,000, is the second off the California coast. Monterey Oil Company operates the similar island near Seal Beach.

★ **Newmont Oil Company** is joining Monterey Oil Company in its offshore exploratory campaign off the California coast. The agreement is the second made by Monterey since April, when that firm and The Texas Company combined forces for tidelands exploration. Under the new agreement, Newmont will share equally with Monterey in its 50 per cent interest in the joint venture with The Texas Company. Monterey will continue to act as operator in the area south of the Ventura-Los Angeles County line while Texaco will act as operator north of that line.

★ **"Mr. Gus"** has walked away from a wildcat off the Texas Coast leaving a dry hole costing more than $1,000,000. The mobile platform has just recently completed the well for Shell Oil Company and Continental Oil Company on a block 63 miles out from Galveston. The expensive duster was drilled in 93 ft of water and was carried to a total depth of 13,386 ft in 51 days. The cost was said to figure nearly $20,000 per day, excluding lease exploration costs. The well, Federal Block A-104 No. 1, was drilled on the 103,680-acre "Neptune Block," purchased from the government for a bonus of $5,500,000. Costs incidental to staking the location were said to run about $30,000.

★ **The Offshore Company,** contract drillers operating from headquarters in Baton Rouge, Louisiana, will be shifting its allegience from the Southern Production Company, its current owner, to Southern Natural Gas Company. Southern Natural has acquired 67.55 per cent of the capital stock of Offshore through a recent contract. Offshore, now active in the Gulf Coast tidelands, will strengthen Southern's position to bid for or obtain from other operators leases or participations covering submerged lands, a company spokesman has indicated.

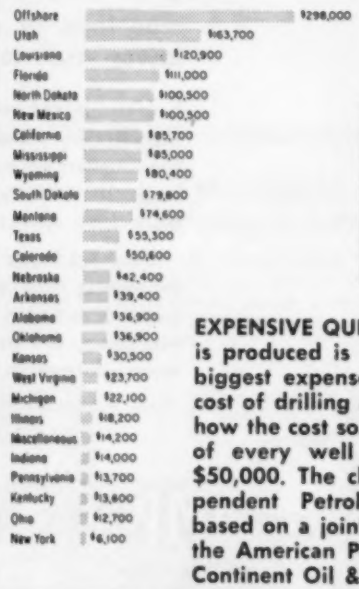
★ **New drilling** in the 39-year-old Garber field in Garfield County, Oklahoma, has turned up production from formations bypassed in earlier development work. Sinclair Oil & Gas has drilled four successful producers in as many months in the area which it had given up drilling five years ago. The new development, says Sincair, was agitated by a young geologist who was convinced that there was still more oil in the field. Old production came from the Hoy sand at a depth of 1130 to 56 ft; new oil is being tapped from the second Wilcox at a depth of about 4500 ft. Latest completion is the No. 36 Denker, brought in flowing 417 bbl a day through a 24/64-in. choke. Garber field was brought in with a 200-bbl oiler in 1917. At its peak in 1925, some 760 wells were producing 71,785 bbl of oil a day.

★ **New deep drilling fluids** developed by Magnolia Petroleum Company's research department will now be offered industry-wide. The fluids, called surfactant muds, were used in the world's deepest well drilled in South Louisiana last year by Richardson & Bass and John Mecom. In the new fluids, conventional constitutents such as lime, caustic soda, and organic thinners are eliminated. These are replaced by a "nonionic surfactant" — a detergent-like organic compound that changes the surface properties of the solid materials in the mud, permitting close control of flow properties even under temperatures above 300F. Most muds deteriorate and solidify quickly above this temperature, commonly encountered in today's 15,000 ft-plus wells. New mud is being licensed by Magnolia and sold through regular mud supply companies.

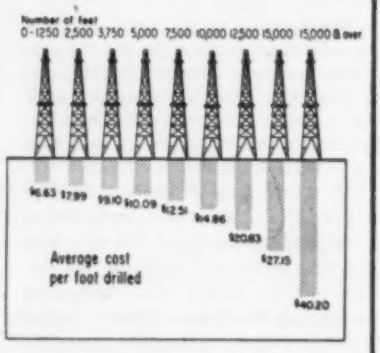
★ **Old time drilling tools** will be displayed as a part of San Antonio's seventieth anniversary of the discovery of oil in Bexar County, Texas. The cele-

COST OF OIL & GAS WELL DRILLING, BY STATES

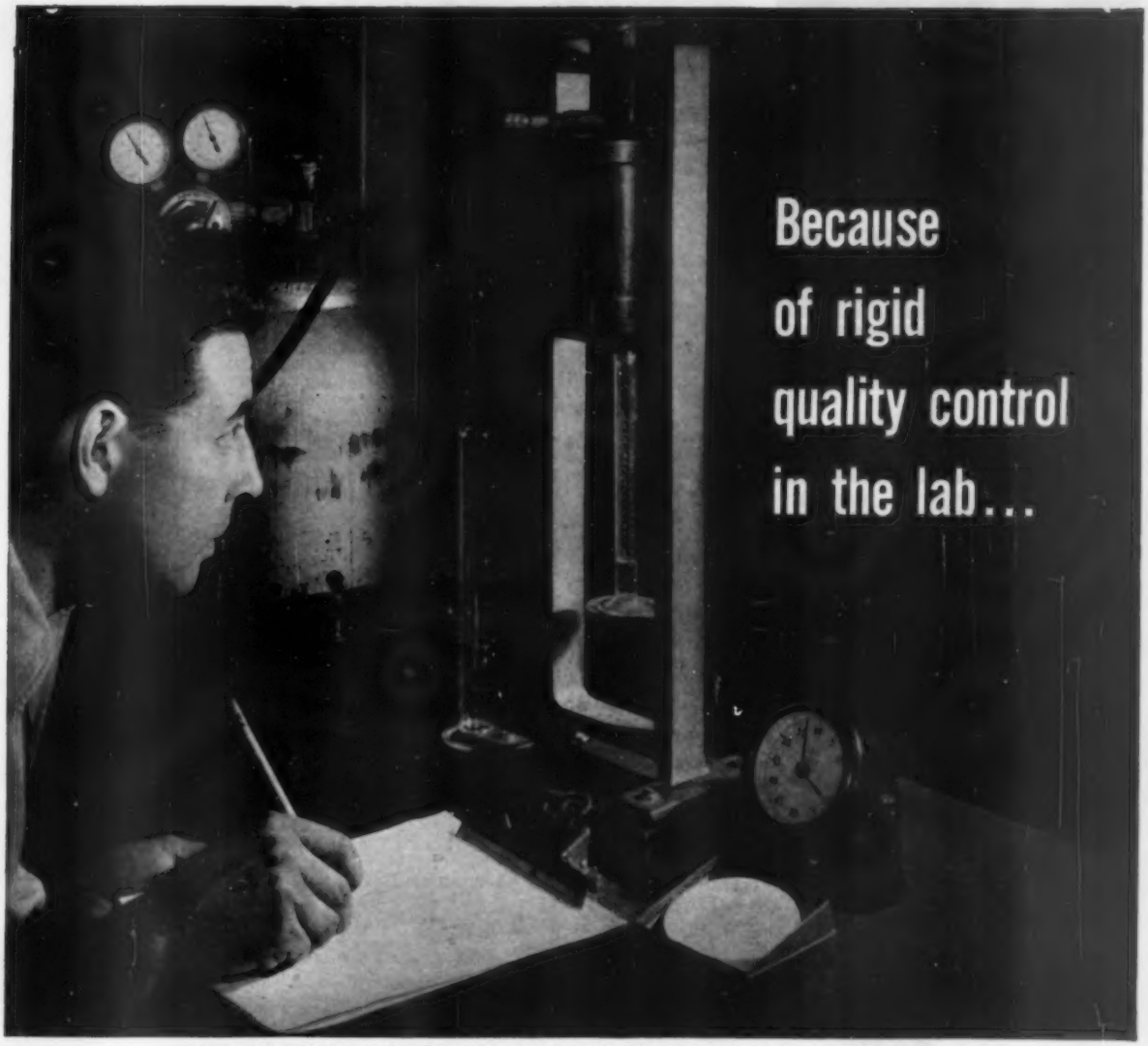
AVERAGE COST PER WELL DRILLED (BY STATES, 1953)



COST BY DEPTH RANGES



EXPENSIVE QUEST — Replacing oil and gas that is produced is the U. S. oil and gas industry's biggest expense. The chart shows the average cost of drilling a well in the various states, and how the cost soars with depth. The average cost of every well drilled in the U. S. exceeds $50,000. The chart was prepared by the Independent Petroleum Association of America, based on a joint industry-wide survey by IPAA, the American Petroleum Institute and the Mid-Continent Oil & Gas Assn.



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B-187

Rotary Rigs Operating in Oil Fields of United States and Canada*

	Aug 20	Aug 27	Sept 3	Sept 10
Alabama	10	10	7	9
Arkansas	21	20	15	16
Arizona	2	0	1	1
California	114	116	111	112
Colorado	58	60	65	69
Florida	1	1	1	2
Georgia	0	0	0	0
Illinois	79	88	84	72
Indiana	8	11	8	8
Iowa	1	1	1	1
Kansas	158	171	161	159
Kentucky	14	9	12	12
North Louisiana	64	63	60	63
South Louisiana	378	375	380	371
Total Louisiana	442	438	440	434
Maryland	0	0	0	0
Michigan	14	14	13	13
Missouri	1	1	1	1
Montana	55	54	49	47
Mississippi	20	23	28	34
Nebraska	30	29	28	26
Nevada	1	1	1	1

	Aug 20	Aug 27	Sept 3	Sept 10
New Mexico	139	135	143	145
New York	1	1	0	0
North Carolina	0	0	0	0
North Dakota	28	25	27	25
Ohio	2	2	1	1
Oklahoma	263	265	271	255
Oregon	0	0	0	0
Pennsylvania	6	6	5	6
South Dakota	0	0	0	0
Tennessee	0	0	0	0
Texas Gulf Coast	232	233	235	237
West Texas	339	330	334	345
North Texas	301	308	301	300
East Texas	63	71	66	65
Total Texas	935	942	936	947
Utah	26	24	23	25
Washington	1	1	0	0
West Virginia	2	2	2	1
Wyoming	77	86	89	85
United States	2509	2536	2523	2507
Western Canada	275	257	264	255
Grand Total	2784	2793	2787	2762

*As reported to the American Association of Oilwell Drilling Contractors by Hughes Tool Company.

bration, in addition to the 70-year-old drilling equipment feature, will bring a modern drilling rig to the steps of the Alamo. Date of the southwestern Texas oldtimers' "chinfest" is October 11-14.

★ **Silver Fox Drilling Company,** Tulsa, Oklahoma, is now owned entirely by John W. Owen, its president. Pat Murta, partner in the firm, has sold his interest to Owen and is opening an office in Tulsa as consulting engineer.

★ **The N. V. Duncan Drilling Company,** Fairfield, Illinois, has been formed by Thomas N. Duncan as president and Paul Duncan as secretary-treasurer. The company is now operating five rotaries.

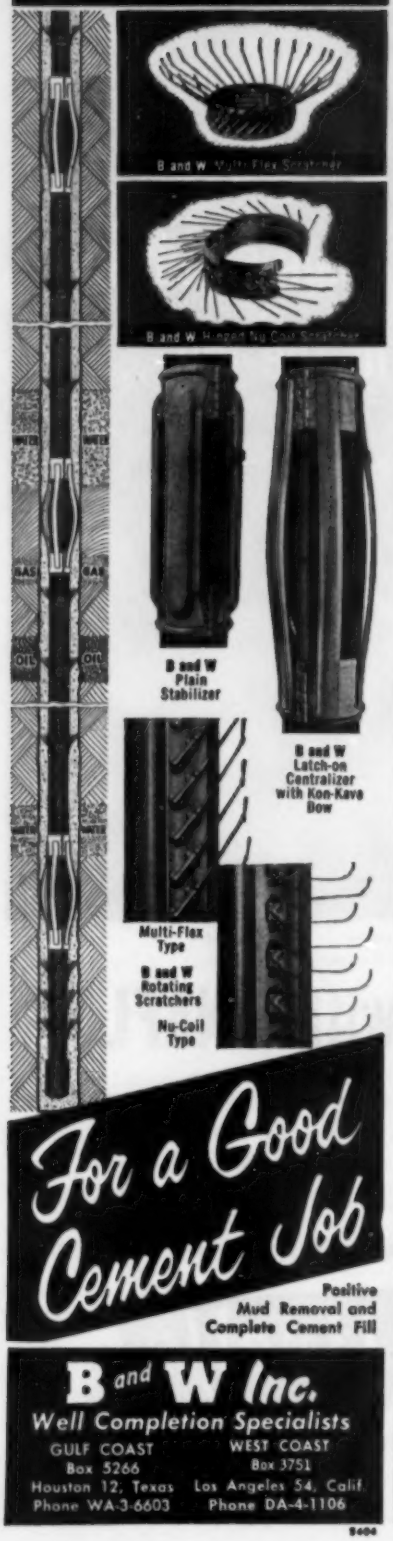
★ **Mesker Drilling Corporation,** Tulsa, Oklahoma, has been granted a 50-year operating charter by the Oklahoma Secretary of State. Officers of firm, incorporated with $125,000 capital stock, are R. F. Mesker, Jack Harden and Sue O. Rourke.

★ **Fast moving Anschutz Drilling Company,** Denver, Colorado, has turned up five new oil and gas discoveries in south central and western Kansas. Anschutz, incorporated just last December, owns 12 rigs and has interests in over 100 producing oil and gas wells in Colorado, Kansas, Nebraska, Texas and Wyoming. Two of the most recent successes are the No. 1 Sniffen in Sheridan County, and the No. 1 Ackerman in Stafford County, Kansas. Both wells have been completed in the Kansas City lime. Initial production from the Ackerman is 392 bbl of oil, with two commercial gas zones tested. The Sniffen well is a good potential discovery at a depth of 3849-76 ft in an extremely porous section of the Kansas City limestone.

★ **Three helicopters** will be used to transport and service two drilling rigs in the jungles of Papua (New Guinea). Operating the new 10,000-ft rigs are Australasian Company, Ltd., and Island Exploration Company, Ltd., who have been engaged in oil exploration in New Guinea since before World War II. The mass air-shuttle operation is slated to get underway early next year. Much of the drilling equipment is already on order. Drillsite clearing is in progress.

★ **Buildup of natural gas reserves** in the Wise County area of North Texas is continuing at a fast pace by Christie, Mitchell & Mitchell. Johnny Mitchell, a partner in the Houston, Texas, firm, has announced that his company plans to drill about 26 wells this year and about 100 in 1957. CM&M has completed 103 shutin gas wells since 1952. These wells are awaiting a pipe line outlet, scheduled to be laid into the area by Natural Gas Pipe Line Company of America. Drilling of the wells is still on an exploratory basis to determine the extent of the gas area. Gas production is being established from the Bend or Atoka Conglomerate. CM&M owns the largest amount of acreage — 270,000 acres in the four county area, with Lone Star Producing Company as the second biggest leaseholder. Southern Union Gas is becoming increasingly active in the area.

B and W SCRATCHERS AND CENTRALIZERS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August 13, 1956

Wilson Manufacturing Co.
600 Block on North Scott St.
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ATTN: Mr. John Wilson

Gentlemen:

RE: Our telephone conversation, several days back on performance of the Super Titan "56" Rig purchased from you in October, 1955.

This equipment was placed in service on our drill barge #1, on November 29, 1955 and thru June 30, 1956, the equipment drilled and completed 14 wells, 4 of which were completed as dual producers.

The average depth drilled was 9000'. Total days elapsed time 215. Total time used for completing wells, after casing was run and tubing picked up, 86 days. Total time moving on location, drilling and running casing and picking tubing up was 129 days.

With the above record it should not be necessary for me to point out that we have had very little lost time on equipment, and that we are completely satisfied with this new type Wilson rig.

Yours very truly,

REBSTOCK & REEVES DRILLING COMPANY

R. H. Reeves

Mr. R. H. Reeves (left) and Mr. John Wilson of Wilson Manufacturing Co. stand on the floor of the Rebstock and Reeves Barge No. 1 during recent operations.

*Throughout the Oil Industry "Red Iron" means it's a famous Wilson rig.

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RUNNING TOUR with MEN in the INDUSTRY

E. V. Corps, exploration manager, Pakistan Petroleum, Ltd., has retired after 26 years of oil industry service in the East. He has left Karachi to return to the United Kingdom.

E. V. Corps

Corps, who has also been manager of PPL for a time, joined the Burmah Oil Company in 1930 as a geologist. He was appointed PPL's exploration manager in 1953. Corps was elected vice president of the Mining, Geological and Metallurgical Institute of India in 1953.

Clyde K. Parker of Wichita, Kansas, has been named district landman for Cities Service Oil Company at Amarillo, Texas. **Robert A. Clark** will replace Parker at Wichita as landman.

Parker has a law degree from Southern Methodist University and joined Cities Service as landman at Fort Worth, Texas in 1951. Clark has been with Cities Service since 1954, working as a landman on special assignments. He is a graduate of the University of Wichita.

Robert W. (Bob) Griffith has been named assistant to the vice president and manager of Sunray Mid-Continent Oil Company's production department, and **L. G. (Gayle) Rodgers** will succeed Griffith as manager of the gas division of the production department.

Griffith and Rogers both joined Sunray in 1948.

Lynn Walker has been appointed to the newly created post of reservoir and evaluations engineer of American Maracaibo Company, New York.

For the past six years, Walker has been with the Creole Petroleum Corporation in Venezuela as reservoir engineer in both eastern and western divisions.

Walker was graduated from Baylor University in 1949 with a BS in physics and mathematics.

Jack W. Williamson has joined H. J. Gruy and Associates. His previous experience includes five years with Continental Oil Company where he served as production engineer.

J. W. Williamson

R. E. Campbell

Roy E. Campbell has become a partner in the consulting petroleum engineering firm of Leibrock and Landreth. The firm will now be known as Leibrock, Landreth and Campbell.

Formerly with Stanolind Oil and Gas Company, he was engaged as group leader of the firm's district office production engineering section.

Dr. James A. Tong and **H. R. Moorman** have been elected president and executive vice president, respectively, of Socony Mobil Oil Company de Venezuela.

Tong, formerly executive vice president, joined Socony Mobil, Venezuela, as a geologist in 1934.

Moorman, until recently manager and executive vice president of Socony Mobil's Canadian affiliate, Mobil Oil of Canada, Ltd., began with Socony Mobil in 1939.

Arthur F. Truex, veteran division manager of Sun Oil Company's Mid-Continent production division, will retire from active service December 31. **George W. Chapman,** land department manager of Sun's southwest division at Dallas, Texas, will succeed Truex.

When Truex retires, he will have completed over 32 years of service with Sun, being division manager for 12 years. Chapman has been with Sun since 1930.

Frank Steen

Frank Steen has been appointed assistant to the president in charge of public relations for Southern Geophysical Company. Steen will headquarter in Fort Worth, Texas, home offices. He was formerly employed by oil industry service and supply companies.

G. A. Stovall

George A. Stovall has been appointed head of the reservoir engineering section, production department of The Vickers Petroleum Company, Inc. **E. C. Abrahamson** has been promoted to division geologist.

George W. Brewer, Jr. and **Glenn F. Thomas** have formed a new company, Thomas and Brewer, to be headquartered in Liberal, Kansas, with operations covering portions of Colorado, Kansas, Oklahoma, and Texas.

Both were formerly employed in the Liberal, Kansas, district of Lion Oil Company. Brewer served as district landman and Thomas as district geologist.

M. D. McBride has accepted the position of manager of the Mesa Drilling Company, Denver, Colorado, the Rocky Mountain division of Camay Drilling Company of Compton, California. He will make his headquarters in Denver.

McBride was formerly with Arrow Drilling Company serving as vice president.

S. P. (Bud) Mandell, formerly vice president and manager of Batex Oil Company, Dallas, Texas, has organized a new company to be known as El Tigre Oils, Ltd. El Tigre, with offices in Dallas, Texas, will initiate an active exploratory program in the North Texas area as well as in South Central Oklahoma.

J. L. Johnson, Jr.

Joe L. Johnson, Jr., petroleum engineer, has joined the staff of Cable Engineering, Wichita Falls, Texas. He was previously with Phillips Petroleum Company in Borger, Texas, serving as production engineer and participated in designing the first automatic lease control with pipe line custody transfer. He holds degrees in petroleum engineering and mechanical engineering from Texas A&M.

Henry C. Cortes has been elected vice president for offshore operations by Magnolia Petroleum Company. He will retain his present duties as company director responsible for Magnolia's field research laboratories.

Stuart Mosson, formerly assistant manager of the natural gas department, was named coordinator of all offshore operations and will work under Cortes' direction.

John W. Clark, former chief geologist for Magnolia, has been named assistant manager of the exploration division.

Philip H. Jennings will become chief geologist for the company, from the position of assistant chief geologist.

John E. Orrell has been named chief mechanical engineer for Shell Oil Company's Pacific Coast area. He started his oil industry career in Shell's Tulsa office in 1935 and his most recent assignment was at The Hague, Netherlands, and in the company's New York office.

Kenneth G. Grandall has opened consulting petroleum and natural gas engineering offices in Houston, Texas. He will specialize in valuation and management of oil and gas properties. His 13 years past experience includes engineering positions with The Texas Company, Phillips Petroleum Company, and a Houston consulting engineering firm.

Dr. Carl O. Tongberg was elected a vice president and director of The Carter Oil Company. He will be in charge of production research activities conducted by Carter on behalf of the producing affiliates of Standard Oil. Tongberg formerly was vice president and director of Esso Research and Engineering Company, subsidiary of Standard Oil Company, Linden, New Jersey.

H. D. Henderson

H. D. (Deep) Henderson has joined Trunkline Gas Company of Houston, Texas, as manager of production and supply. He will supervise the company's gas supply, gas reserves, and geological departments and will direct the organization of a production department.

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Fig. 100
1000 psi
Sizes: 2"-8"

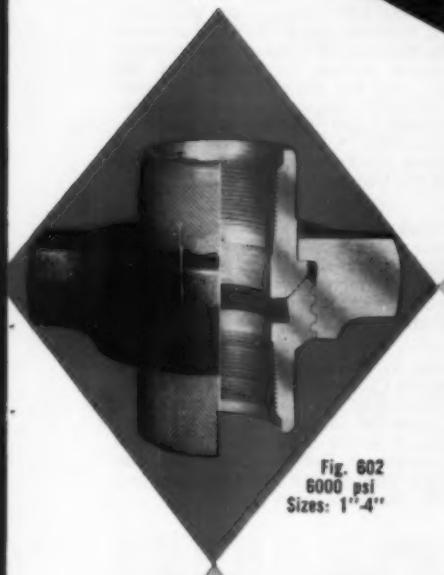

Fig. 602
6000 psi
Sizes: 1"-4"

Fig. 400
4000 psi
Sizes: 6"-12"

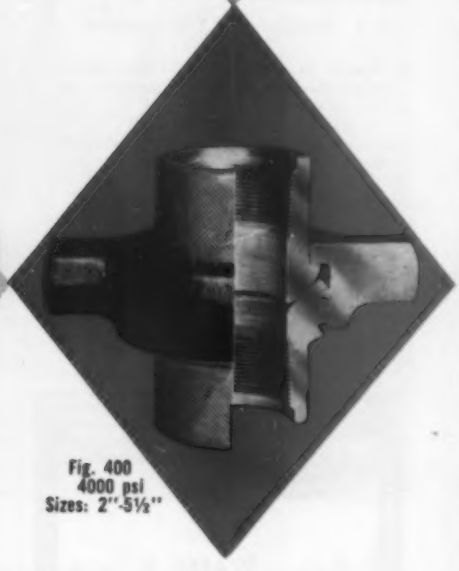

Fig. 400
4000 psi
Sizes: 2"-5½"

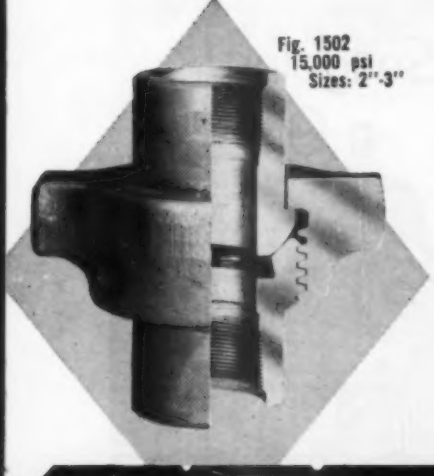

Fig. 1502
15,000 psi
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A. B. Macaulay has been appointed to the newly created position of assistant to the vice president and general manager of The Atlantic Refining Company's crude oil production department.

Succeeding Macaulay as manager of Atlantic's domestic production administrative division is **Clarence E. Cardwell, Jr.** Cardwell, who joined Atlantic in 1947, formerly has been assistant to the manager of the West Texas-New Mexico region.

A. B. Macaulay

M.H.Mitchell

Martin H. Mitchell has been named general manager of Tidewater Oil Company's operations in Turkey.

In his new post he will direct oil exploration of land held under exploratory licenses by Tidewater jointly with Atlantic Refining Company and Seaboard Oil Company.

Maury M. Travis has announced the opening of his office as unit geologist consultant specializing in oil and gas units and participating areas, federal and state lands; federal and state hearings.

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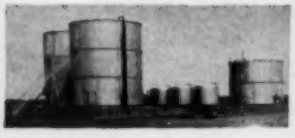

Strawn Sand
Water Flood
Wichita County
Texas

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ESTIMATES
DESIGN
INSTALLATION
SUPERVISION

PETROLEUM ENGINEERS
CABLE ENGINEERING
WICHITA FALLS, TEXAS

H. M. Temple

C. H. Calvert

Howard M. Temple and **C. H. Calvert, Jr.** have been appointed secretary and production manager, respectively, of Commonwealth Oil Company of Houston.

Temple formerly was legal adviser to the Pan American Production Company's land department. Calvert was assistant division superintendent of D. D. Feldman Oil and Gas Company.

Both men will serve in similar capacities in the Marine Gathering Company, a Commonwealth subsidiary.

E. J. Gemmill

J. M. Armstrong

E. J. Gemmill of Fort Worth, Texas, has been appointed assistant division manager for Cities Service Oil Company's southwestern exploration division and **John M. Armstrong** of Midland, Texas, as southwestern division geophysicist.

Gemmill steps into the new position of assistant division manager from the post of southwestern geophysicist. He joined the company in 1935 after his graduation from the University of Colorado. Armstrong began his career in 1949 after graduating from the University of Kansas with a degree in petroleum engineering and geology.

S. D. Blattner, supervisor, and **T. R. Warrick,** geophysicist, have been transferred from Magnolia Petroleum Company's office in Dallas to the district office in New Orleans, Louisiana.

D. R. Dobyns, supervisor, **A. J. Oden,** geophysicist, and **Alice Wetterau,** computer, are now located at Magnolia's district office in Oklahoma City, Oklahoma, having been transferred there from the home office at Dallas.

J. C. Eley, supervisor, and **E. J. Medley,** geophysicist, have been transferred from Magnolia's home office at Dallas to the district office at Roswell, New Mexico.

George W. Isensee, supervisor, **W. M. Tottenham,** geophysicist, and **Mrs. Noralee Pope,** computer, have been transferred from Magnolia's office in Dallas to the Houston, Texas, office.

J. S. Page, supervisor, has been transferred from Magnolia's home office at Dallas to the Lake Charles, Louisiana, office.

Albert J. Alcott, district civil engineer at Magnolia's Duncan district will be transferred from the civil engineering department to the producing operating department in the capacity of assistant foreman at the same location.

John R. Dunlap, a resident of Libya, North Africa, has joined the Oasis Oil Company of Libya, a subsidiary of the Ohio Oil Company. He will be on the geological staff.

A native of Philadelphia, he was graduated from Utah State Agricultural College in geology. He later worked as a geologist in Tulsa, Oklahoma, and New York City before joining Conorada Petroleum Corporation in Libya in 1954.

William M. Quackenbush has joined the staff of Statex Petroleum, a subsidiary of State Exploration Company, Los Angeles, California, as geologist and will be located in Amarillo, Texas.

He was formerly with Continental Oil Company where he was assistant to the director of a four company offshore group in California.

William L. Peyton, Houston, Texas, has been promoted to division geologist for Continental Oil Company, with headquarters in Midland, Texas. Formerly assistant to the manager of Conoco's headquarters geological section, he succeeds **H. H. Bybee,** who has transferred to the company's CATC marine region at Houston.

Peyton joined Conoco in Oklahoma City in 1948. A native of Texarkana, he received his bachelor's degree in 1948 from the University of Oklahoma.

Joseph Neely has been promoted to assistant chief geologist, exploration department, Magnolia Petroleum Company. **Walter L. Moreman,** exploration department, has been appointed as general staff geologist.

John L. Redmond, geologist for The Ohio Oil Company at Calgary, has been transferred to the company's subsidiary, the Oasis Oil Company of Libya, North Africa. A native of Canada, Redmond is a graduate of University of Tulsa, has worked through the Mid-Continent and Rocky Mountain areas.

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Oil Metering's WELL TESTER, with a rating of 99.99%, is the most accurate oil, gas, and water separating and measuring unit of its kind available.

Low initial cost and dependable, trouble-free operation make it an economical production and test unit. Simplicity of design and ease of operation keep costs down. Simple controls and adjustments make it practical, versatile. Each WELL TESTER is engineered to meet your requirements.

It combines an oil, gas and water separator with the type and size VOL-U-METER† required to solve your metering problem. Available in working pressures from 125 to 3000 PSI. Individual units have maximum liquid capacities as high as 4000 BPD, and gas capacities up to 10 MMSCFD.

Skid or trailer mounted, WELL TESTERS have proven themselves practical and accurate for: • Gas-oil ratio tests • Periodic production tests • Drill stem tests • Marginal well tests • Potential tests • Reservoir study tests • Producing dual completed wells into common battery • Tax and royalty payments (commingling oil from multiple leases) • Checking production in unitized operations • Test separators at tank batteries • Automatic lease operation.

TO SOLVE YOUR METERING PROBLEM, WRITE OIL METERING FOR MORE INFORMATION ON WELL TESTERS

OIL METERING and Processing EQUIPMENT CORP.
MELROSE 5-1226 • 4843 YALE STREET
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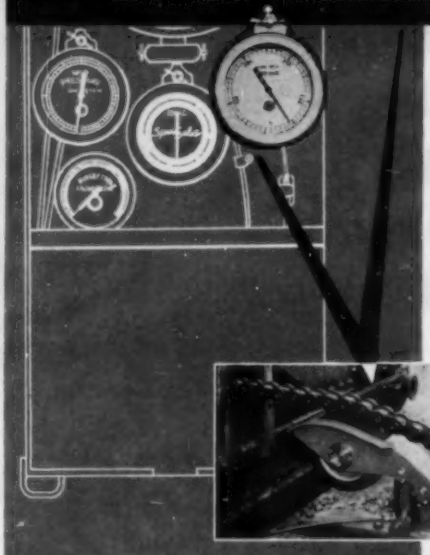
Sales and service representatives in all major oil fields

Easily installed on any chain-driven rotary.

Responds to the slightest torque changes.

Adjustable for net-torque-on-bottom.

WHY MANY OPERATORS DEMAND HYDRO-MECHS ON ALL THEIR RIGS



Easy to move from well to well.

Stabilizes chain and gives it longer life.

Models for single or double-link chains.

The Hydro-Mech idler assembly rides under the rotary chain and transmits hydraulic impulses to a gauge in the drilling-control panel or in any other convenient spot.

Torque is one of the most important variables in any drilling operation — with too little, you're wasting men and equipment; with too much, you're courting an expensive twist-off. Recognizing these pitfalls, more and more contractors and operators are demanding that their rigs be equipped with Hydro-Mech torque gauges. Compared to a $10,000 fishing job, the cost of a Hydro-Mech is certainly negligible.

Distributed through Reed, National, and other recognized supply houses.

MARTIN-DECKER CORP.
HOME OF THE WEIGHT INDICATOR — LONG BEACH, CALIFORNIA

THE WEATHERFORD TECHNIQUE

Your cement job is in good hands

The Weatherford Technique is your best assurance of a good cement job . . . the most advanced method known for the proper conditioning of the hole, preparatory to and during the running and cementing of casing.

But it is more than that; the Weatherford Technique is the combination of men, equipment, know-how, and service that is being used by operators throughout the world for the successful production of pipeline oil.

The man from Weatherford: (1) surveys the well condition after the electrical log has been run, (2) recommends the proper type, number and spacing of scratchers and centralizers, (3) supplies and installs the equipment on the casing, (4) recommends the proper make-up of the cement slurry and the optimum running time, (5) expertly supervises the entire program, and (6) prepares a complete well report on the casing and cementing operation.

This Technique is indispensable to safe and economical completions. The man from Weatherford gives the job all he's got. You get a better cement job, more profit and less worry.

WEATHERFORD
OIL TOOL CO., INC.

GENERAL OFFICES: 5920 Navigation Blvd., Houston, Texas

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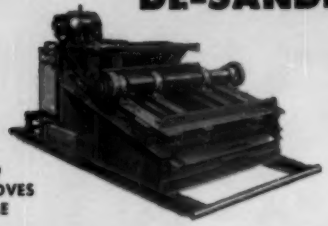
ALWAYS IN OPERATION WHEN PUMPS ARE RUNNING

NEW MODEL RUMBA DE-SANDER



ALSO REMOVES SHALE

HUTCHISON MANUFACTURING CO.

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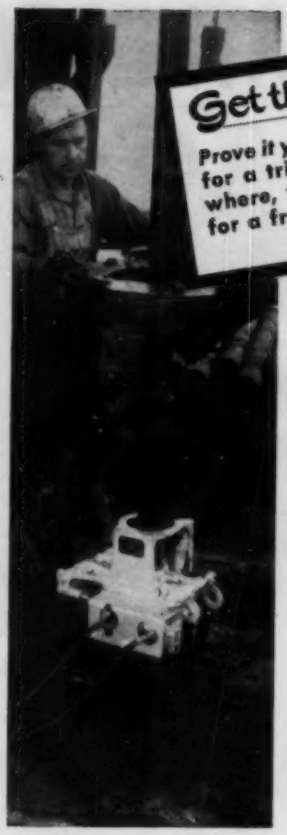

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Prove it yourself—use the ADVANCE for a trial period, anytime, anywhere, without obligation. Write for a free demonstration.

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air powered
TUBING SPIDER

The **ADVANCE** is the first and only complete Automatic Air-powered Tubing Spider. It is also available for hydraulic operation. It is full of features that you'll not find in any of its imitations.

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What the WELL-DRESSED, MEDIUM-PRESSURE Wells are wearing

This well is equipped with the compact "Tee Base Type" HERCULES Duplex Stuffing Box and HERCULES "Type SO" Tubing Head. The Tubing Head is equipped with HERCULES original overhead packing arrangement and self-aligning hinged slips, making this a simple yet complete hook-up, featuring safety with simplicity and minimum of parts.

AVAILABLE THROUGH ALL SUPPLY STORES

If you have any problems involving well head equipment, a phone call, telegram or letter will bring you the desired information — quick.

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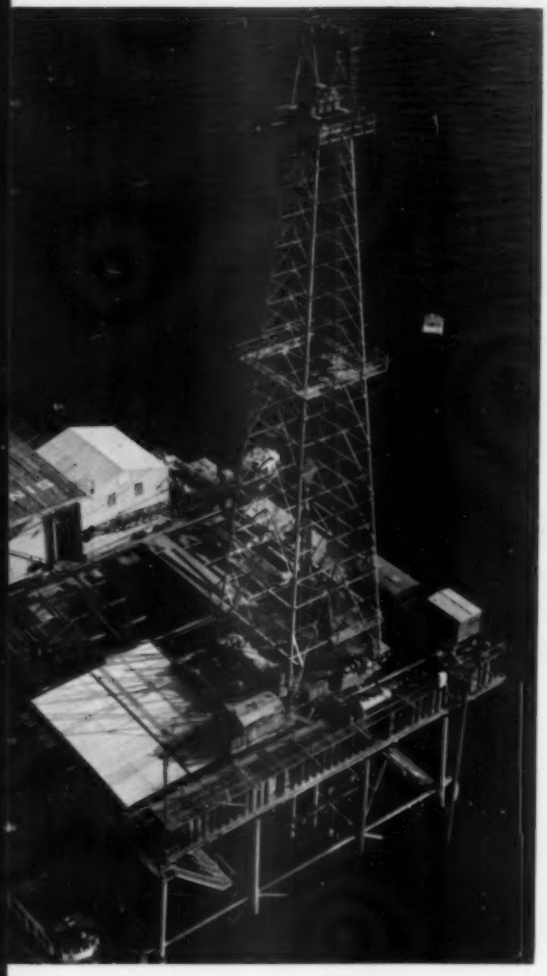
MANUFACTURERS OF OIL FIELD EQUIPMENT SINCE 1924

GENERAL OFFICES AND PLANT TULSA, OKLAHOMA

Export Representative: Oil Field Equipment Co., Inc., 30 Church Street, New York 7, N. Y.



DESIGNED FOR THE JOB . . .

Offshore

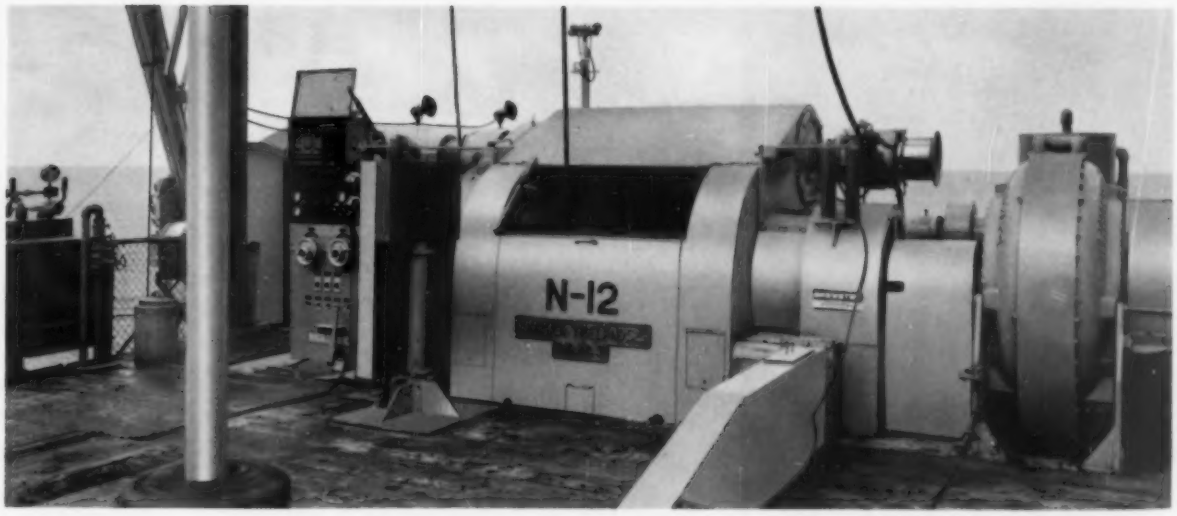
Brewster N-12 with Rigelectric

Here is a team that is winning the race for more speed and power on deep offshore wells . . . Brewster N-12 with Rigelectric Power.

Now at work in LaFourche Field, this Brewster built Rimrock Tidelands Rig 3 has the power and stamina to drill the worlds deepest well.

Working with Rigelectric equipment men, Brewster engineered the N-12 drawworks to obtain maximum advantage of diesel-electric power. At a touch of the controls the driller can put 1,250 horsepower at the drum to speed a long string of drill pipe off bottom. With equal ease he can direct 1,875 horsepower to the mud pumps . . . start or stop any auxiliary . . . all without effort, or leaving his position at the control panel.

The smooth flow of full horsepower for every drilling task is bringing new speed and economy into the offshore picture. You can take advantage of this diesel-electric manufacturing experience by calling in Brewster when your new offshore venture is in the planning stage. Ask today for the Brewster N-12 Rigelectric offshore story . . .



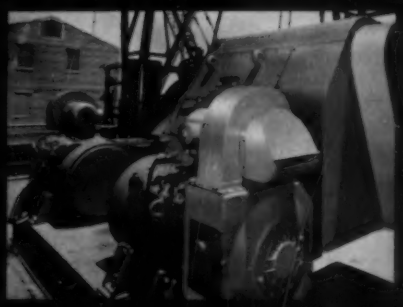
BREWSTER N-12 DRAWWORKS

2000 HORSEPOWER AT THE DRILLER'S COMMAND

Amazingly simple the control panel for the N-12 electric rig gives the driller effortless command of every operation. His full attention can be concentrated on the job, which promotes greater crew safety and faster drilling.
Mounted as an integral part of the drawworks, the control panel need not be disconnected when moving the rig.

1250 HORSEPOWER AT THE DRAWWORKS

Designed for the job . . . the N-12 drawworks transmission is equipped with dual input drives each connected to a 625-hp. electric motor. The two-speed transmission, coupled with high and low drives at the drum, gives four hoisting ratios to supplement the infinite speed range possible with the electric motors. Short in length the drawworks package requires a minimum of deck room . . . can be skidded around to permit six or 12 well drilling.

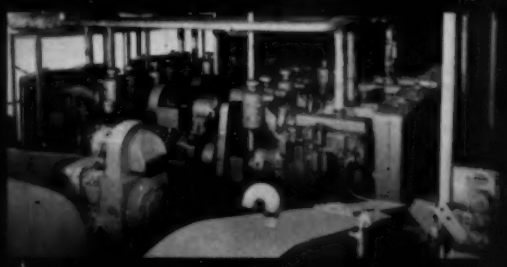


1875 HORSEPOWER AT THE MUD PUMPS

Flexibility of equipment placement is of major importance on space-limited offshore platforms. One 16-inch pump has been unitized completely with 625-hp. electric motor. One 18-inch pump has been unitized with 2 – 625-hp. electric motors. They can be skidded into the most favorable position for manifolding to the mud lines. Only an electric cable need be laid to obtain full driving power.

2000 HORSEPOWER AT THE GENERATORS

Completely packaged the Rigelectric generating units occupy a minimum of space . . . can be placed anywhere on the platform without regard to drawworks or pump location. Individually skidded as single units, the generator sets require only connection to fuel lines to go to work.



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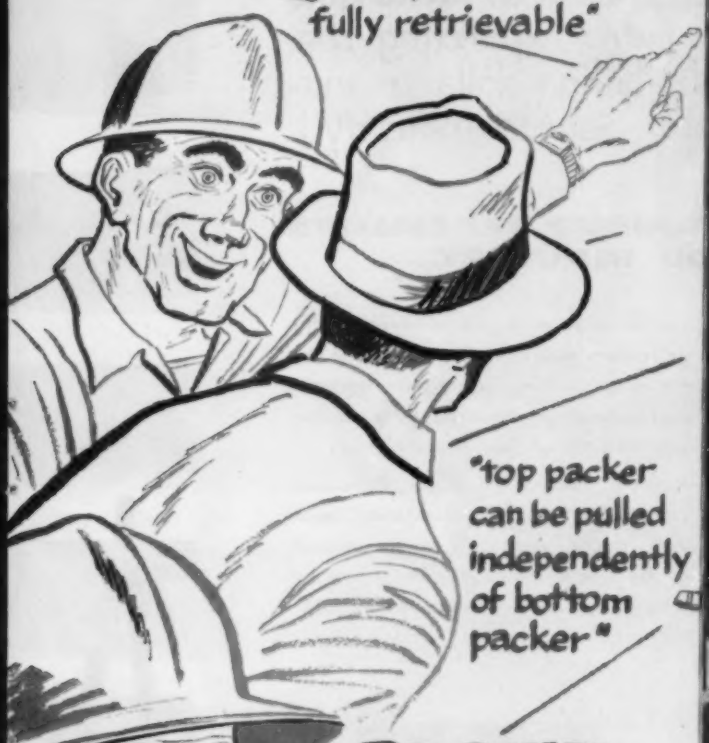
THE BEST DUAL COMPLETION

BROWN DS-8

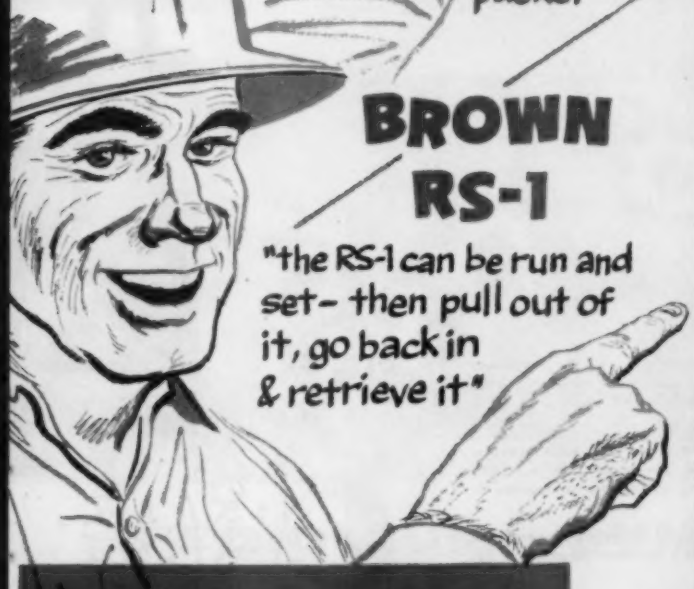
"both packers fully retrievable"



"top packer can be pulled independently of bottom packer"

BROWN RS-1

"the RS-1 can be run and set- then pull out of it, go back in & retrieve it"



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HOUSTON, TEXAS

DUAL STRING PACKER

"runs both packers simultaneously"

"saves time- saves money!"

For further information, write: Brown Oil Tools, Inc.

BOT

IF YOU HAVE A PACKER PROBLEM — BROWN CAN HELP

9,000 *

furnish the technological **Know How** for advancing and expanding the dynamic multi-billion dollar manufacture-supply-service industry!

HOW THESE HIGHLY TRAINED SPECIALISTS BENEFIT THE GREAT OIL INDUSTRY...

TO KEEP ahead of the requirements of the gigantic and fast growing oil industry, top managements of the companies serving it have taken the long range view in providing engineering talent that anticipates and meets the demands of unprecedented growth.

Few machines, even in this machine age, have to operate regularly under such a combination of great stresses, high temperatures, abrasive and corrosive action as do the machines in the petroleum industry. To meet these extreme conditions, scientists, engineers and technologists are regularly producing miracles of mechanics.

Member companies of the Petroleum Equipment Suppliers Association regularly apply practically every branch of scientific knowledge to the solving of their customers' problems having to do with drilling, producing, and servicing.

*** The petroleum manufacture-supply-service industry is in the highest bracket of large industries regularly using a very high percentage of specially trained scientists, engineers, and technicians. Based on estimates made from a recent survey, there are over 9,000 divided as follows:**

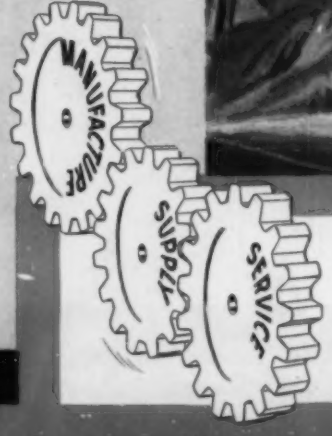
765	Research Scientists and Technologists
1840	Development Engineers for both product and service
445	Metallurgists and Technicians in Metallurgy
855	Engineers Engaged in Production Inspection and Final Inspection
5583	Field and Service Engineers

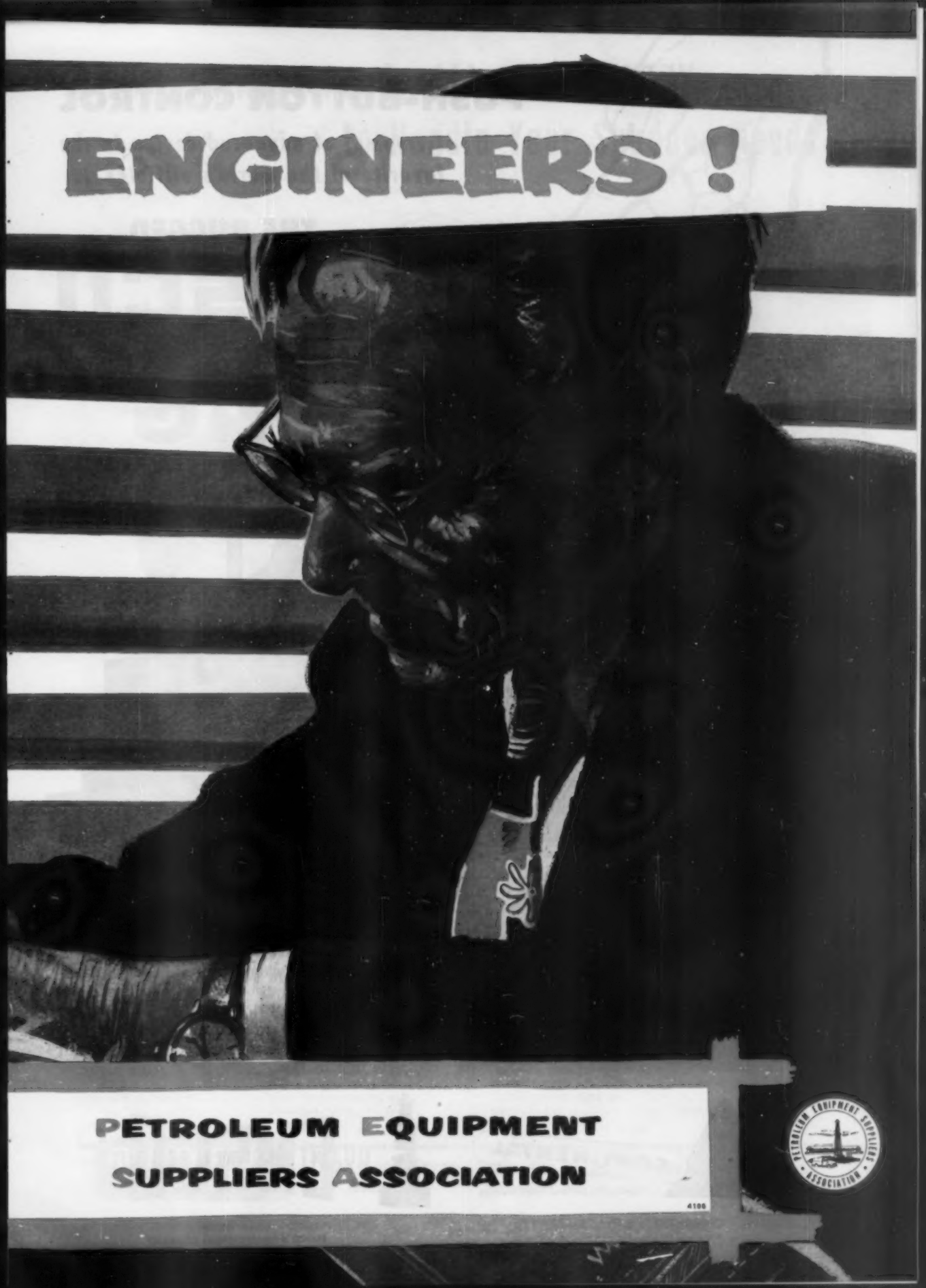
BIG SERVICE FOR A SMALL PROFIT VISION AND FAITH

That the service is big is shown by the heavy investment of manufacture-supply-service companies in scientific and engineering talent, and in billions of dollars in plant and equipment.

That the profit is small and the vision and faith great is shown by: 1. the small average dividends paid — 1.74%; 2. the average earnings plowed back into the building up of the companies in order to better serve the oil industry — 4.76%.

The petroleum manufacture-supply-service industry is truly rendering progressive, intelligent, and conscientious service to one of the world's greatest industries — oil.

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PETROLEUM EQUIPMENT
SUPPLIERS ASSOCIATION
4100

PUSH-BUTTON CONTROL

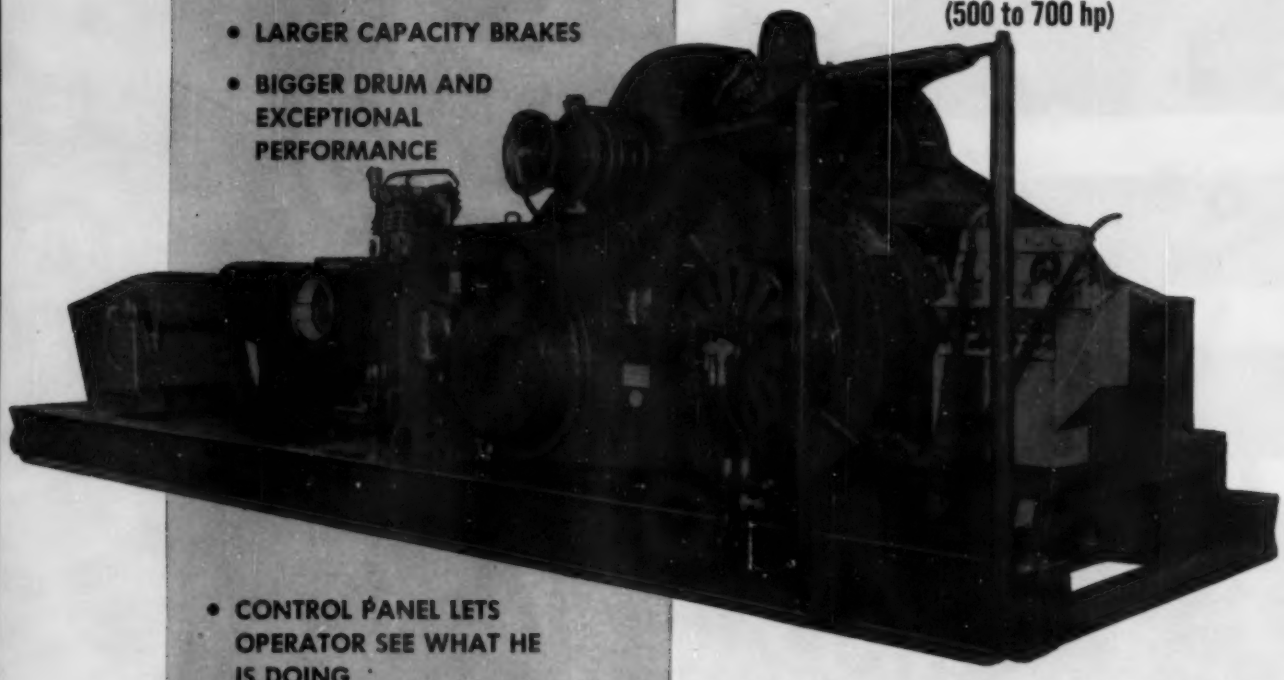
...typical of advanced design in the favorite of the world's oilfields...

THE RUGGED EMSCO GC-500 RIG

(500 to 700 hp)

ADVANCED DESIGN ASSURES YOU:

- **EFFICIENT LUBRICATION SYSTEM**
- **LARGER CAPACITY BRAKES**
- **BIGGER DRUM AND EXCEPTIONAL PERFORMANCE**



- **CONTROL PANEL LETS OPERATOR SEE WHAT HE IS DOING**

All gauges, operating valves and push-button controls are mounted in a separate console to assure the driller full view of the floor and derrick operations.

A trouble-free pressure oil system completely lubricates the rig from pump countershaft to drumshaft. Larger capacity brakes, exclusively designed by Emsco, provide smooth dependable braking action. Bigger drum is 22" spool diameter by 45" long. There are many other advantages. Call a Continental salesman today for bulletin and complete information.

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R606

Always Ready, Able and NEARBY to Handle Your Spudder Needs

Here's an up-to-date list of 39 distributor outlets for Bucyrus-Erie spudders, located throughout the United States and Canada in every major oil field. There's a distributor near YOU—*always ready* to fill your equipment needs, *always able* to provide fast, dependable parts, tools and repair service. See him soon and take advantage of his years of field experience, wealth of cost-cutting ideas, and eagerness to satisfy. He's in business to help *you make money* . . . to analyze your drilling problems and to recommend ways *you can solve them.* And you will do BOTH with Bucyrus-Eries.

FIRST with the FINEST in Spudders

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CABLE TOOL SUPPLY CO. . . . . Princeton, Ind.
DRILLERS SUPPLY CO. . . . . . Joplin, Mo.
DRILLING AND MINING EQUIPMENT CO. . . . . . Los Angeles, Calif.
GREAT NORTHERN TOOL & SUPPLY CO. . . . . . Billings, Cut Bank and Kevin, Mont.; Casper, Wyo.
IVERSON SUPPLY CO. . . . . . Tulsa, Oklahoma City and Okmulgee, Okla.; Ft. Worth, Dallas, Midland, Odessa and Snyder, Tex.; Artesia and Farmington, N.M.
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PEPTOMAGIC
MATERIAL FOR USE WITH LOW GRAVITY CRUDE OR FUEL OILS TO PRODUCE AN OIL BASE MUD
OIL BASE, INC.
COMPTON-HOUSTON
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50 LBS. NET
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50 LBS. NET

ECONOMAGIC and PEPTOMAGIC are concentrated oil base drilling fluid materials and are especially suited for overseas operations or wherever transportation costs are high. For the most profitable use of these products consult your OBI representative.

for *FASTER* completions

PEPTOMAGIC

MIXED WITH CRUDE OIL

Prevents water blocking and mudding off producing zone. Deposits a thin mud cake that dissolves in crude oil. Weight materials held in suspension by "peptization." Works well at high temperatures.

PEPTOMAGIC is mixed with a low-gravity (16° to 30°) asphaltic-type crude oil (or fuel oil) and is used primarily for completing wells. It drills a hole to gauge, thereby eliminating one of the most frequent causes of stuck pipe. Any water picked up during drilling is emulsified. PEPTOMAGIC eliminates costly clean-up operations and gets the well on production faster. 10 pounds per barrel of crude oil is adequate.

for *ECONOMICAL* workovers

ECONOMAGIC

MIXED WITH CRUDE OIL

A low-cost, low-weight oil base mud material that is mixed with crude oil. Particularly recommended for wells requiring a minimum weight oil base mud with maximum plastering properties. Deposits a paper-thin special type mud cake that gives maximum protection to the producing formation and tends to prevent lost circulation. Under normal temperatures, does not lose water with the filtrate.

ECONOMAGIC is mixed with a low gravity (16° to 30°) asphaltic-type crude oil (or fuel oil). Ten pounds of ECONOMAGIC per barrel of crude oil is suitable for an excellent light weight mud. ECONOMAGIC is unaffected by salt, cement, anhydrite, etc. ECONOMAGIC is the economical, effective way to reduce lost circulation where plastering is the chief problem. It is *not* recommended where hole temperatures are high nor under circumstances requiring excellent weight material suspension ability.

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RECTOR type "M"

..the Tubing Head that's WAY ahead

..in Flexibility

MANDREL HANGERS

Type "A" Mandrel Hanger threaded for EUE or regular tubing.

Type "M" Stripper for tubing heads with locking screws.

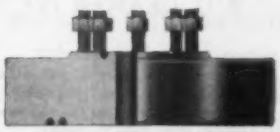
Type "A-O" Mandrel Hanger threaded, also grooved for locking screws. The "O" Ring serves as temporary seal.

Type "WM" Wrap-Around Mandrel. It is hinged to wrap around tubing; also grooved for locking screws.

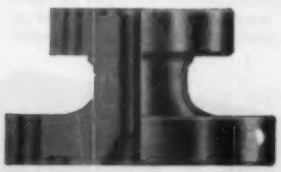
Type "C" "Slick Joint" Mandrel grooved for locking screws. The "O" Ring serves as temporary seal.

BONNETS

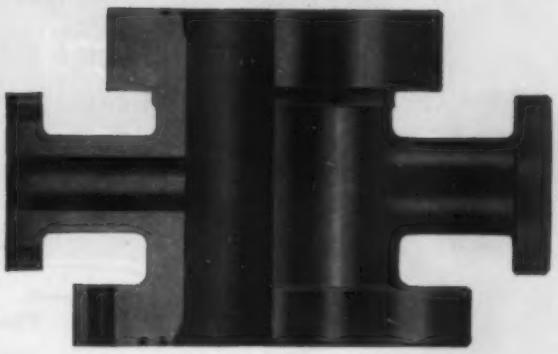
Male threaded bonnet also available with underside female threaded to hang tubing.



Studded bonnet also available with underside female threaded to hang tubing.



Spool-type bonnet also available with underside female threaded to hang tubing.



• **The wide range of body types (6), the complete range of pressures (2,000 to 15,000 lb. test), the variety of mandrel hangers and bonnets (10) . . . all of which are interchangeable in the bodies, plus auxiliary equipment, make it possible to select a Rector Type "M" Tubing Head for every well completion condition and preference.**

Every one of these heads employs the proven Rector principle of sealing with steel . . . a single API Ring Gasket acting dually as seal and hanger hold-down. There are no soft or resilient seals in these heads to deterioriate, burn out, freeze or contract in extremely low temperatures.

When planning well completions . . . specifying Christmas Trees . . . specify a Rector Type "M" Tubing Head for the utmost in safety and flexibility.

For complete specifications of all Type "M" Tubing Heads, Mandrels and Bonnets, see the Composite Catalog.

RECTOR WELL EQUIPMENT COMPANY INC

MAKING THE OIL INDUSTRY SAFER

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REPRESENTATIVES IN ALL ACTIVE FIELDS

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WILSON *Fishing Tools*

SAVE YOU MONEY

When you have a Fishing Job — call your nearest Wilson Supply Company Store, or telephone:

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The *Right* Tools and *Right* men will save you time and money.

•

The Milling tools and Rotary Shoes shown here have been hard surfaced with crushed Tungsten Carbide.

•

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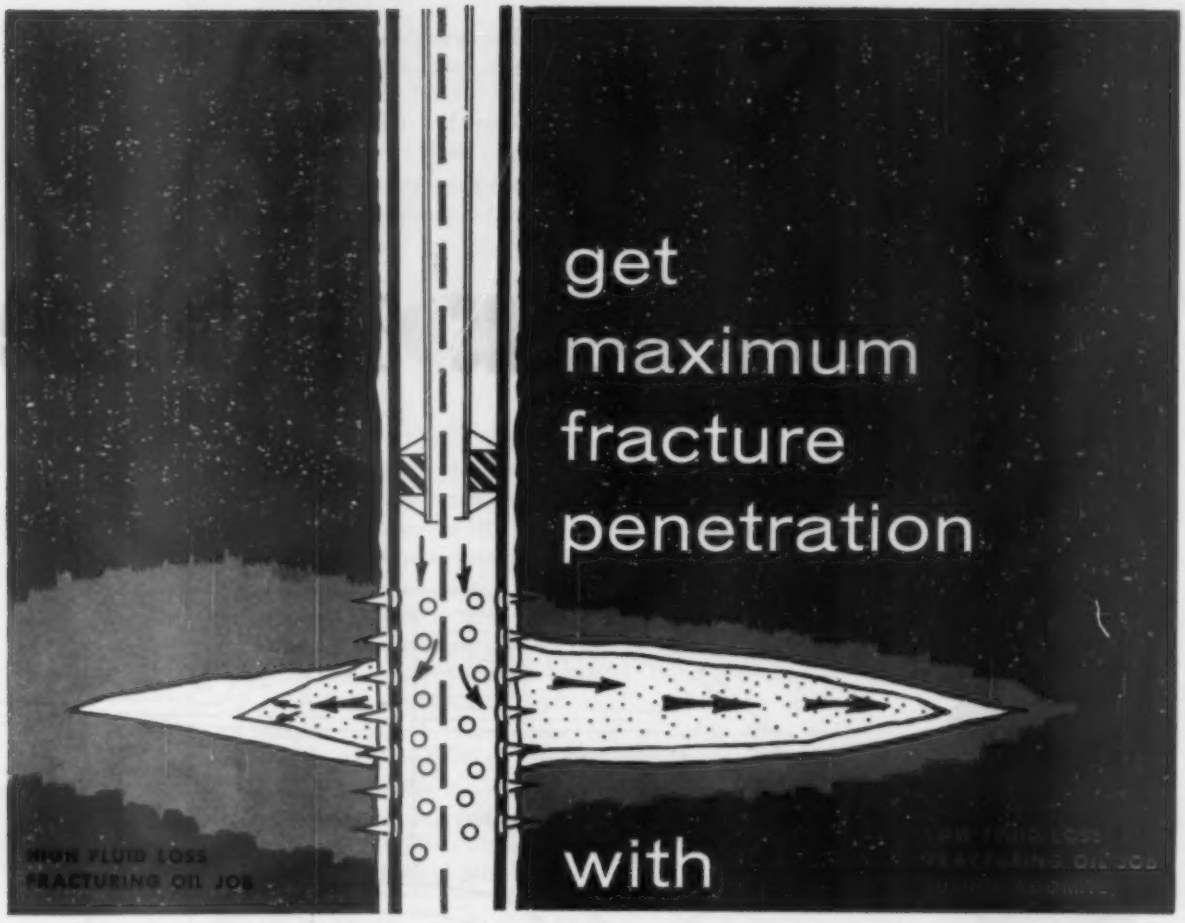

Adomite®

CUTS FLUID LOSS TO LESS THAN 10 CC.'S

(API Code 29 Fluid Loss Test)

Here are some very sound reasons why producers everywhere are fracturing with Adomite, the fluid-loss control agent proven profitable in 10,000 field treatments.

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Adomite—developed and manufactured by Continental Oil Company

Adomite ® trade-mark, Continental Oil Company
© 1956, Continental Oil Company

Seals the fracture face . . . minimizes fluid loss . . . no damage to formation.

Longer fractures . . . deeper penetration of sands.

Fewer sandouts . . . reduces fluid loss in rock matrix, prevents buildup of sand concentrations in the fracture.

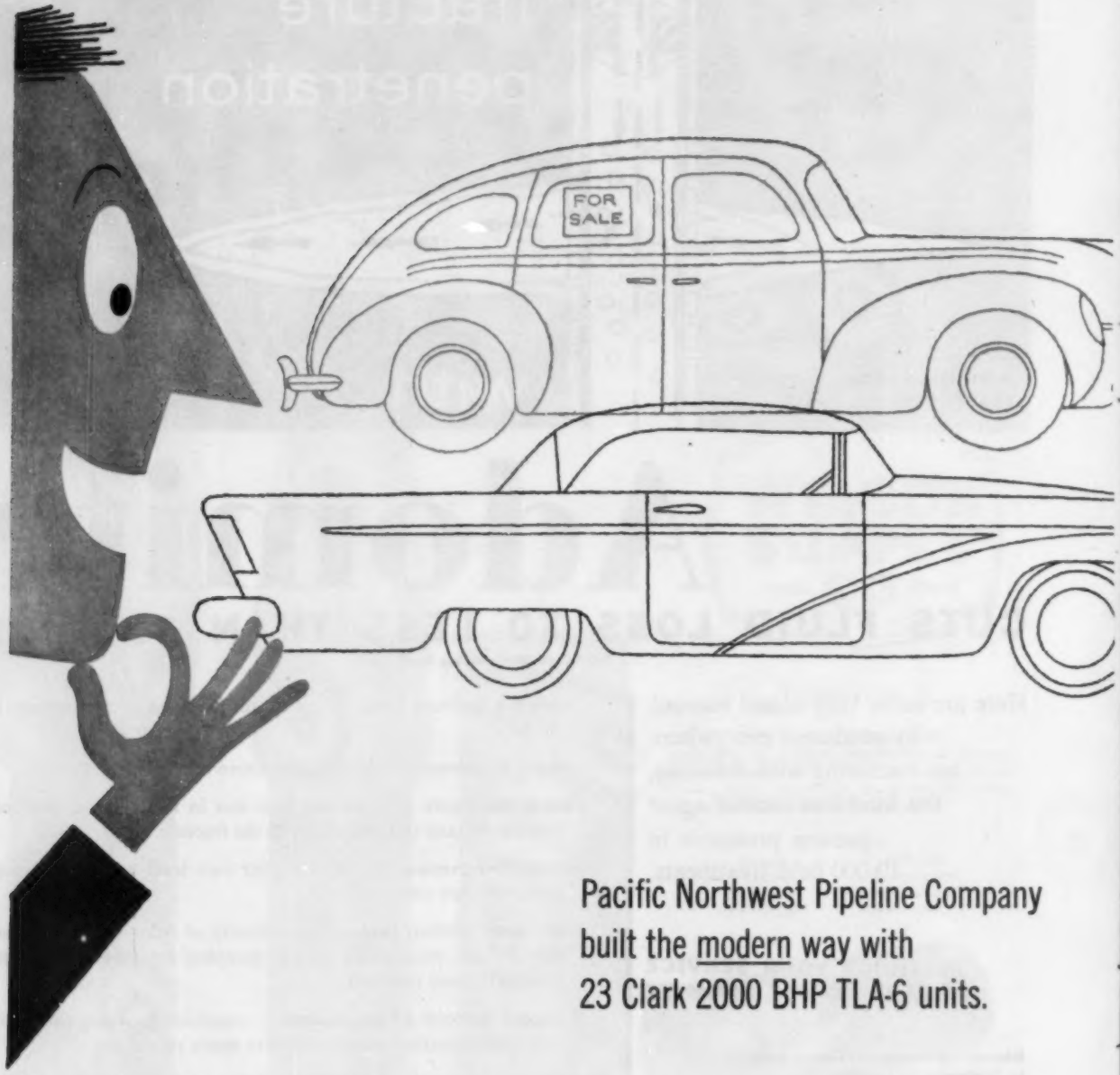
Saves you money . . . utilizes your own lease crudes . . . saves transportation costs.

Decreases friction loss . . . low viscosity of Adomite-created fracturing fluids permits use of less pumping equipment than with viscous refinery residuals.

Reduces hazard of emulsions . . . emulsion-breaking characteristics are important consideration to many producers.

Adomite, and **only Adomite** is all you need to control fluid loss of kerosene, crudes, gelled crudes or refinery residuals.

compressor designs also become



Pacific Northwest Pipeline Company
built the modern way with
23 Clark 2000 BHP TLA-6 units.

New automobile designs with startling advances in styling and performance present their appearance every year. Engines considered to be the last word a few short years ago, have been scrapped in favor of new models possessing greater performance and stamina.

Isn't there also a continuing need for improved compressor designs and performance . . . don't they too become obsolete?

obsolete!

To avoid owning a *new* plant that is an antique *before* it starts up, be sure that you insist upon modern compressors.

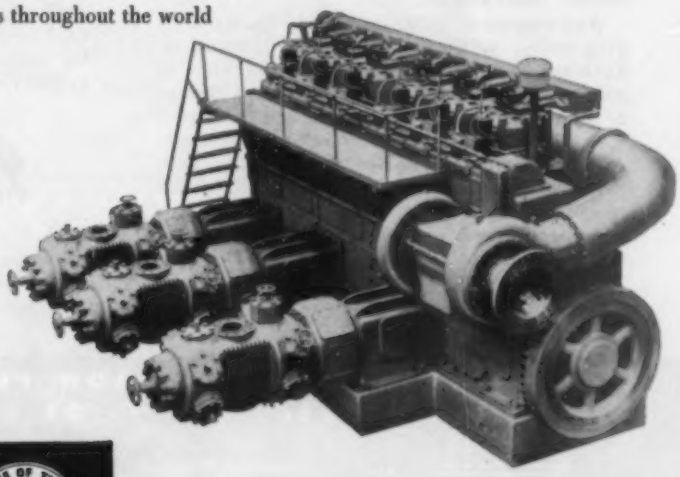
Clark is the only source of MODERN compressors that are specifically designed and built as turbo-supercharged units.

This means high power output—up to 65% more, without cutting into overload capacity or safety factor. Furthermore, a 10—15% reduction in fuel consumption plus a 40% saving in cooling cost is a direct result of turbo-supercharging.

Though Clark Model TLA and TRA Turbo-Supercharged compressors are modern designs, they have already been proved in numerous installations. They are built in 1100—3400 BHP models.

If you would like further details on the advantages of buying MODERN turbo-supercharged compressors to match your other up-to-date equipment and facilities, call your nearest Clark office or write for bulletins No. 134 and 145.

CLARK BROS. CO. • OLEAN, N. Y.
One of the Dresser Industries
Sales offices in principal cities throughout the world



Clark Model TLA-6 2000BHP Turbo-Supercharged, 2-cycle, gas-engine-driven compressor

CLARK®

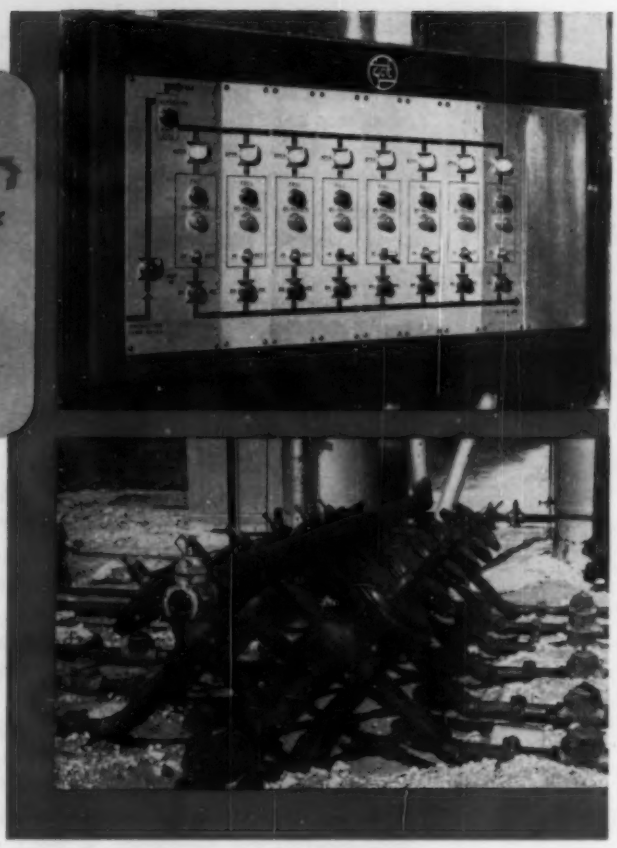
ONE OF THE DRESSER INDUSTRIES

Turbo-Supercharged Compressors

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

got

ELECTRIC LEASE AUTOMATION



Going far beyond the realm of mere "tank switching," GOT Lease Automation encompasses every phase of production control. It begins at the wellhead, and ends with automatic custody transfer. It permits 30-day advance programming of the entire system . . . individual well testing with individually variable test time for each well . . . automatic metering of gas, oil and water, with direct, strip-chart or totalizing-print recording of data.

So accurate and dependable are these systems that all data generally is acceptable to conservation bodies and royalty owners. They reduce production overhead by eliminating the need for individual lease batteries, by giving more accurate control of production, gathering comprehensive information on individual and collective well performance, and by freeing lease personnel for other duties. When combined with remote control facilities, they provide the highest degree of "push-button" operations.

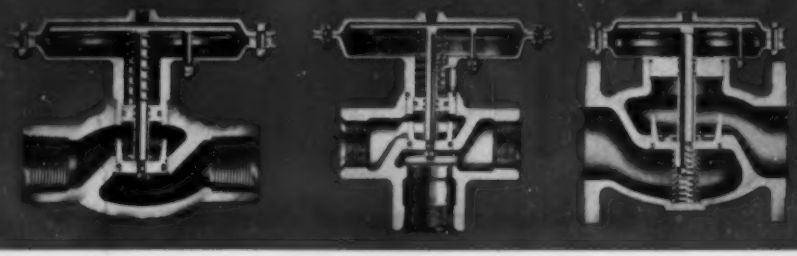
Any degree of automation may be installed originally, with other phases added as desired. A complete turn-key service is offered, including complete system design or engineering assistance, installation, and supervisory services during initial operation. All installations are in accordance with National Electric Code Standards for hazardous areas (Article 500), and all systems are unconditionally guaranteed to give satisfactory service.

For lease automation in its highest development, for the dependability of time-proved components, and for the satisfaction that comes from undivided responsibility, plan your program around GOT systems. Ask your GOT representative for information, or write for literature. **Pneumatic or electro-pnuematic systems are available also.**

Garrett Oil Tools, Inc.
P. O. BOX 2427 • LONGVIEW, TEXAS

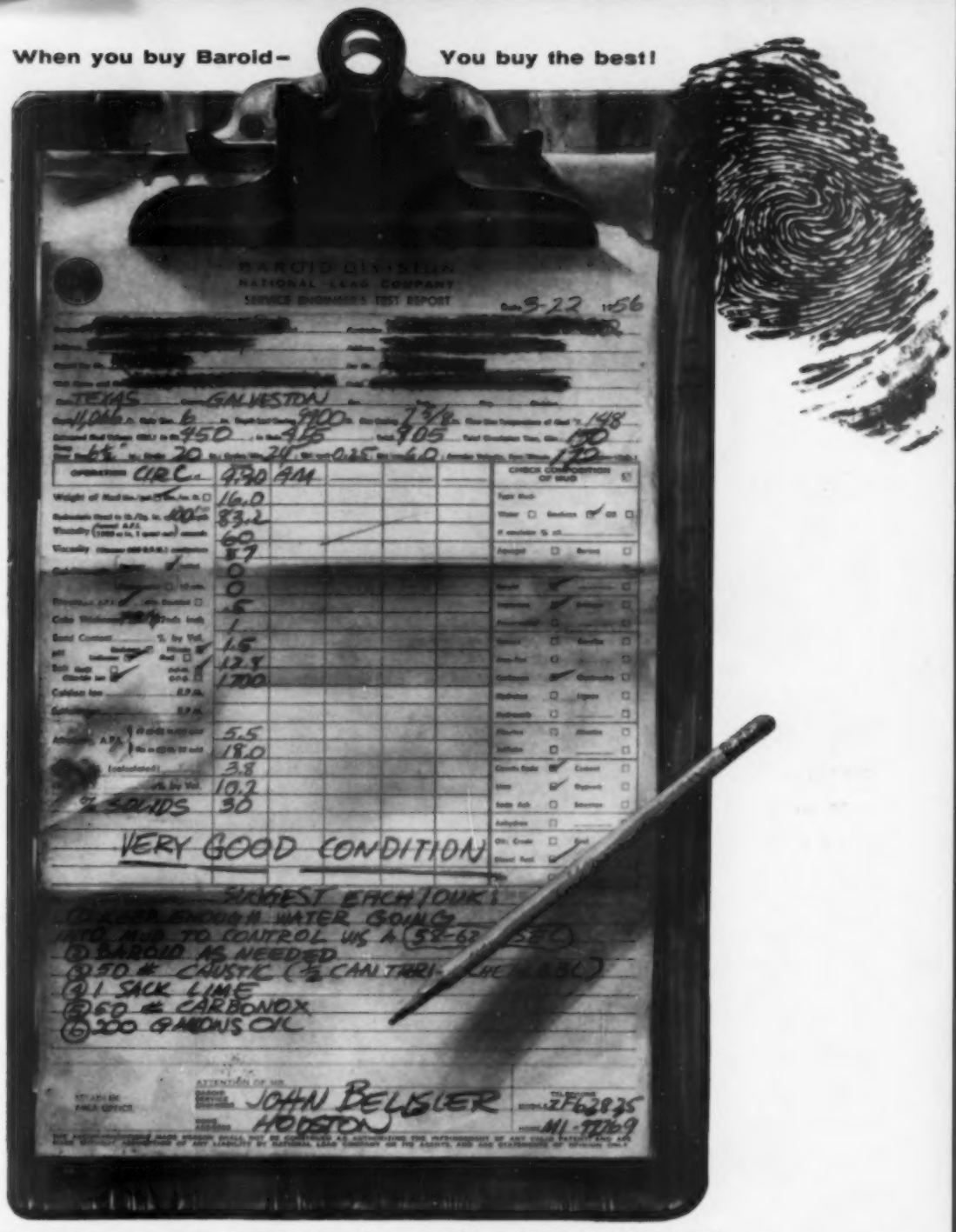
DIVISION OF USI U. S. INDUSTRIES, INC.
New York, N. Y.

A COMPLETE SELECTION OF LOW PRESSURE MOTOR VALVES DESIGNED ESPECIALLY FOR LEASE AUTOMATION



Since no system is better than its valving, Garrett has designed a complete new line of low pressure motor valves. They give the utmost in dependability, at the lowest cost. In addition, a full selection of high pressure valves is available for application where required. Motor Valve Catalog No. 256 MVC will be sent upon request.

When you buy Baroid– You buy the best!



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Main Office: P. O. Box 1675, Houston 1, Texas

Classified at seven Baroid area offices near you are the results of over 1,000,000 mud test reports . . . valuable "fingerprints" of mud programs in your area. Baroid engineers have accurate records there to plan an honest, economical mud program. No other mud company can match these "fingerprint" files. Just one of the reasons why your Baroid mud program costs you less.

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When your mud makes you feel like this...

USE CARBONOX
a Baroid original

No other single mud product can help you lick so many different mud problems: Carbonox is a thinner and gel reducer, an aid in filtration rate control, an efficient emulsifier, and even prevents the tendency of lime muds to solidify at high temperatures.

Ten years of successful field use in all types of mud, all areas and all drilling depths have proved the efficiency and economy of Carbonox.

No wonder mud troubleshooters turn first to Carbonox, another money-saving chemical developed and introduced exclusively by Baroid.

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Rugged Chicago Pneumatic Three Cone Rock Bits are designed to afford deep penetrating action with every turn of the drill stem. Their fast cutting speed enables you to drill more feet a day. They're available in seven different types from soft to exceedingly hard and abrasive formations. *Oil Tool Division, Chicago Pneumatic Tool Company, 5000 U. S. Highway 81 South, Fort Worth, Texas.*

Chicago Pneumatic

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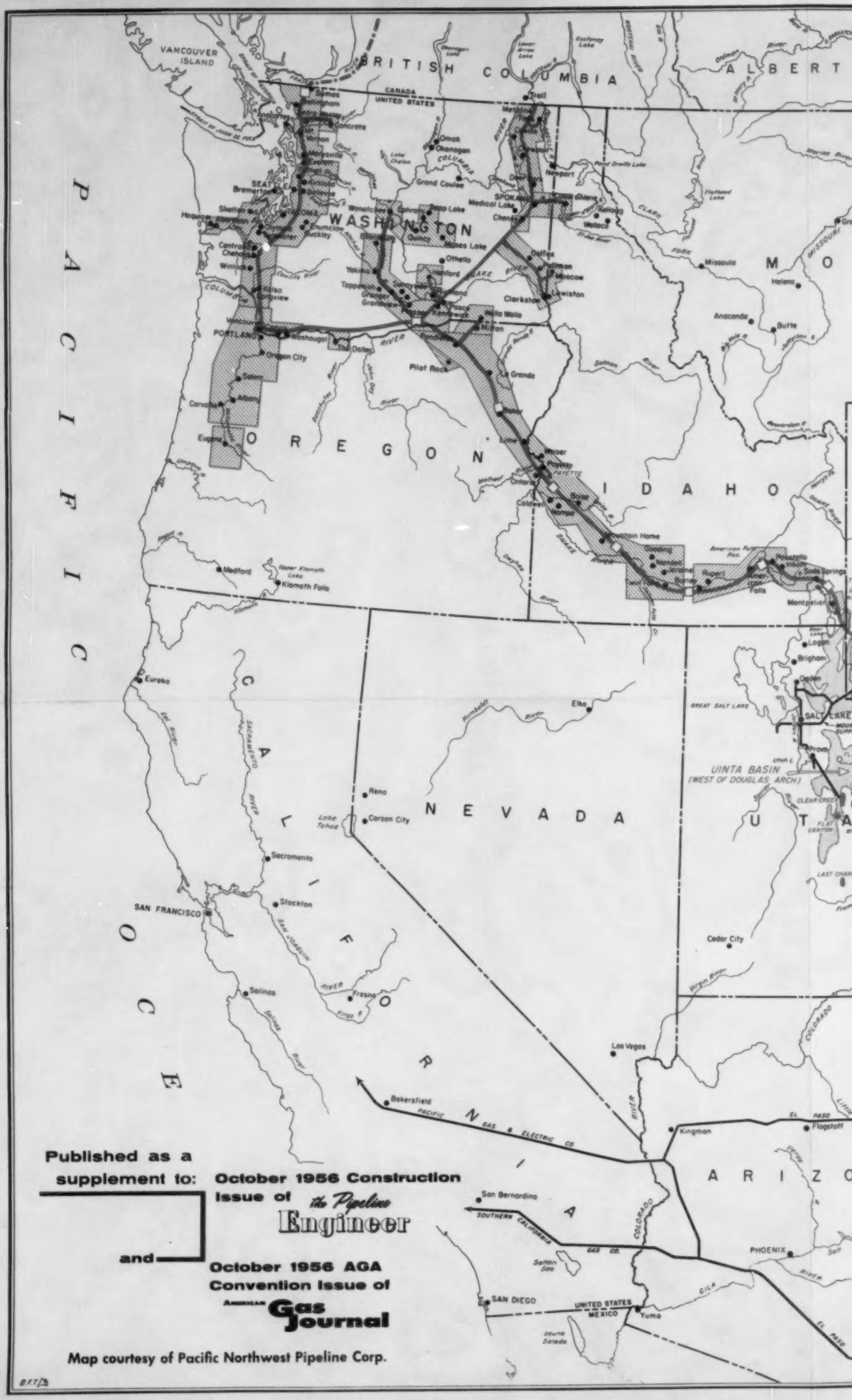
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Lake Tahoe
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Utah Lake
Salton Sea
Mono Lake
Owens Lake
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Pacific Gas & Electric Co
El Paso Natural Gas Co
Southern California Gas Co
Published as a supplement to: October 1956 Construction Issue of the Pipeline Engineer and October 1956 AGA Convention Issue of American Gas Journal
Map courtesy of Pacific Northwest Pipeline Corp.

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HOMCO Directional Drilling Services are built around tools which have been designed and engineered by HOMCO Engineers. Continuous improvement, through research and development, keeps the tools apace with the modern drilling practices. HOMCO offers the industry the most complete selection of Directional Tools and Services. Consult with HOMCO on your next Directional Drilling problem.

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MANY MORE COMPANIES REPORT:

Du Pont CMC Grade DM minimizes fluid loss with low mud viscosity at lower cost than refined CMC or starch

Here's a sampling of what oil companies in various parts of the country say about Grade DM...

LOUISIANA. The Division Mud Engineer of a major company reports on the drilling of their first well using Du Pont CMC Grade DM in place of starch in a lime mud. Savings on initial conversion approximated $350, not including further savings on maintenance for the duration of the well. All field superintendents have been advised that in the future only Du Pont CMC Grade DM will be purchased for wells in this area. The Chief Technical Service Engineer confirms that all reports on Grade DM have been favorable.

MISSISSIPPI. A Production Superintendent of a large company states that he is completely satisfied with the performance of Du Pont CMC Grade DM which is being used in *all* the muds he is now running.

TEXAS. One company reports that only Du Pont CMC Grade DM satisfactorily combines low mud viscosities with excellent suspending action for cuttings and weighting material required to increase mud density. Because of the low viscosities obtained with Grade DM it was unnecessary to use a centrifuge as previously proposed.

LOUISIANA. The Drilling Engineer for an offshore operation states that Du Pont CMC Grade DM worked very well in assisting viscosity control and in maintaining low fluid loss in a sea-water mud. It was the only chemical additive used on this well and has been recommended for several others in the same field.

CALIFORNIA. When refined CMC was used, mud viscosity was too high to permit further addition of refined CMC, and the water loss was over the maximum allowable. Du Pont CMC Grade DM was added and subsequent water loss was below the maximum with no increase in viscosity.

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LOUISIANA. A Field Engineer of a major mud company states that the performance of Du Pont CMC Grade DM has been exceptionally good and that it is now being widely used in coastal Louisiana.

Both land and offshore operations benefit from Du Pont CMC Grade DM. Ask for it at your mud dealer, or locations of Macco Corp. and Barada & Page, Inc., or from E. I. du Pont de Nemours & Co. (Inc.), Explosives Department, Wilson Bldg., 1621 Main St., Dallas, Tex., or Chemical Sales, Wilmington 98, Delaware.

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BETTER THINGS FOR BETTER LIVING ... *THROUGH CHEMISTRY*

"From spud to pay I beef up

US RUBBER

my rigs with 'U. S.' products..."

says toolpusher "Red" Royal

Hard-driving, hard-working "Red" picks "U. S." products to "put muscles" on his rig. He knows from experience that "U. S." products are the *best* insurance against downtime he has ever found. They are designed and made by men who know all about oil field problems—men who are out to help the driller get more and more footage—in less and less time—at less cost.

"I use it all the way from spud to pay—no switching of hose!" says "Red" Royal about U. S. ROYAL 4 ROTARY HOSE.

"In Texas, just one U. S. Royal 4 drilled over 300,000 feet in over 3 years, at a hose cost of less than a penny a foot drilled!" No need to keep money tied up in stand-by hose to finish wells. U. S. Royal 4 handles the highest pressures . . . no downtime in order to switch. No lubrication needed; complete flexibility from nipple to nipple.

"I insist on belts that have *proven* they wear longer. That's why I always see to it that U. S. RAINBOW® V-BELTS are on my rigs."

Take, for instance, this performance record: On a composite drive U. S. Rainbow V-Belts drilled over 218,970 feet of hole, moving from location to location. At last count, they were still on the job after 43 months. The contractor says the belts he had previously used *failed after three wells.*

"Withstands the highest pressures met in today's drilling operations."

U. S. MUD PUMP VIBRATOR HOSE (P-8087).

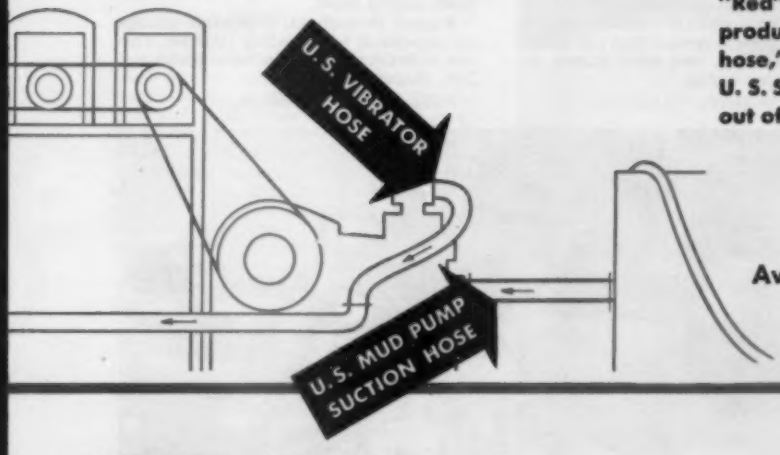
Standard equipment between mud pump and standpipe. Does away with broken pipe and loose connections. Takes up misalignments between mud pump and mud line. Speeds rig-up time.

"The hose that can't collapse!"

U. S. GIANT HEAVY DUTY MUD PUMP SUCTION HOSE P-8048.

High flexibility permits quick adjustment of the intake of the line to the right position in the slush pit without changing connections. This hose keeps air out of the line, prevents mud ends from blowing, reduces wear on valves and pistons, and often saves 2 or more connections in each line. Will not collapse, thanks to heavy spring-steel coil construction. Handles chemically-treated or oil-base mud, or crude oil.

"Red" Royal also relies on plenty of other "U. S." products. "I use other types of 'U. S.' oil field hose," says "Red," "plus 'U. S.' packings and U. S. Super-Service V-Belts. I always get the best out of my rigs, and 'U. S.' helps me do it."



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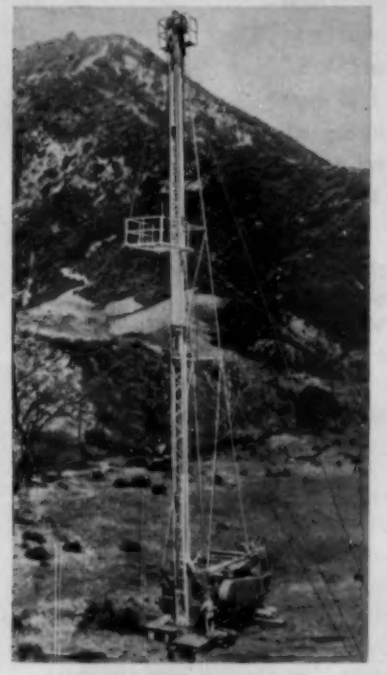
NEW Drilling and Producing Equipment

(1) 85-ft Servicing Derrick. An 85-ft servicing derrick, designed especially to afford added height for rod and tube servicing without sacrificing portability, has been announced by Bucyrus-Erie.



The two-section, power-lowered telescoping derrick lays down over the spudder for fast road travel and is available as special equipment for use with the firm's largest model oil well spudder — the 48-L.

Power-raised, the derrick has a built-in four-part tackle and over-size derrick hoist drum. The derrick can handle up to 60,000-lb of tubing.

Bucyrus-Erie Company.

(2) Ultrasonic Thickness Measurement. An ultrasonic thickness-measuring instrument, the SO-100 Sonizon, has been announced by Magnaflux.

Unit is portable, weighing only 30 lb, at least 20 lighter than previous resonance-type equipment. Its small case, light weight and long (five-foot) search cable make it adaptable for use in constricted areas.

Magnaflux Corporation.

(3) Portable Rotary Compressor. Ingersoll-Rand announces the addition of an 85 cfm size to its line of Gyro-Flo compressors.

With this addition, the Gyro-Flo line of portable compressors has been increased to six sizes — 85 cfm through 900.

The Gyro-Flo 85 weighs only 1840 lb fully equipped with tool boxes, fenders and two-wheel, spring-mounted running gear. The light weight and compactness of this compressor also make it suitable for truck mountings. As a truck-mounted unit, the Gyro-Flo 85 weighs only 1375 lb and stands only 42 in. high.

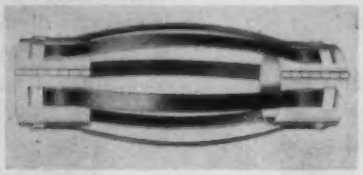
Ingersoll-Rand Company.

(4) Direct-Drive Generating Plants. Two more direct-drive generating plants have been added to the Winco line of engine-generators manufactured by Wincharger.

These Winco units are both designed to run at 1800 rpm. The Winco Series 2B23S4D is rated at 2000 w, while the 102B14S4D is rated at 1250 w, both with plenty of margin for temporary overload.

Wincharger Corporation, a subsidiary of the Zenith Radio Corporation.

(5) Centralizers. Byron Jackson announces the addition of centralizers to its line of oil tools. Product, known as "Red Top" Centralizers, employs a totally new method of cage and spring attachment,



which causes the springs to be pre-stressed in assembly.

The springs are put under tension and inserted into pockets in the cages that maintain the stress. This pre-stressing is counter to the force exerted upon the centralizer in the hole and thereby exerts the maximum centering force when in use.

Byron Jackson Tools, Inc.

(6) Indicator-Recorder for Power Tongs. Martin-Decker has introduced an improved recorder for power tongs which is electrically operated.

The electric wire is claimed to be easier to transport and string than the hydraulic hose used on earlier models. Recorder can be situated completely away from the rig's vibration. If desired, it can be powered by an automobile battery.

Instrument provides a practical method of preventing loose connections and galled threads, miscounts, and other human errors in running casing.

The Martin-Decker Corporation.

(7) "Visigage" Couplings. Designed to permit visual inspection of flow conditions in a flow line, "Visigage" couplings are

available in 2-in. and 2½-in. sizes.

Plastic section is packed off by "O" rings so that it can "float" within the end sections. Overall length of the coupling is 15 in. Units are also designed for pipe line and processing applications.

Handling Equipment Company.

(8) Proportioning and Metering. Infilco has announced the design of an ATI proportioning and metering system. Design and equipment are said to provide an overall accuracy of 2 per cent plus or minus over range of flow from 100 per cent to 10 per cent of rated capacity for equipment used. Advantages of the new system are that it can be used to maintain chemical feed in proportion to flow and affords a measurement of flow on the linear scale.

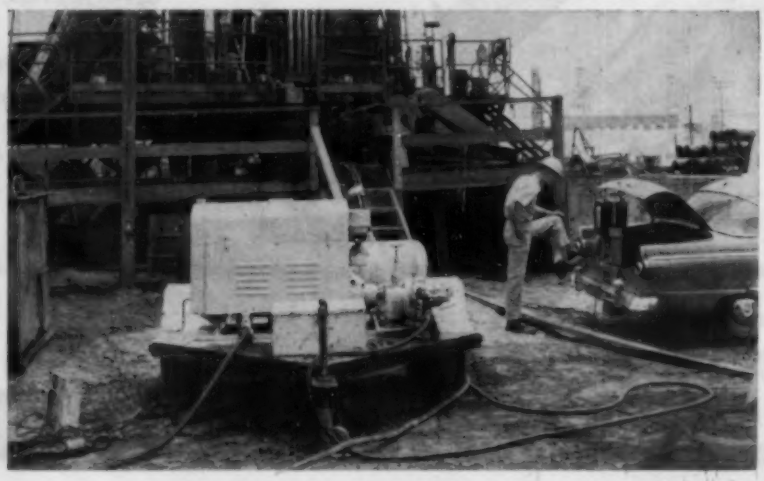
Infilco, Inc.

(9) Stable High-Pressure Regulator. To solve the problem of vertical instability or "jumping" that is sometimes encountered on high-pressure gas transmission lines, Fisher Governor has introduced a high-pressure regulator.

Featured in the Series 883 and 885 regulators is an oil dash-pot which is claimed to dampen out any tendency of the valve to jump, yet will not cause valve to deviate from control point.

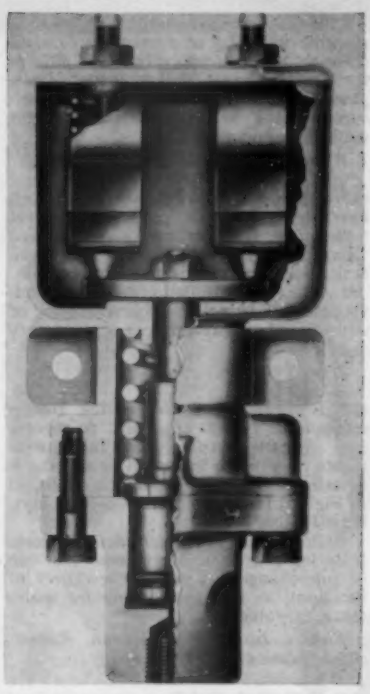
Rugged throughout, diaphragm casings are capable of withstanding 1000 psi. This new series is available in valve body sizes 2-in. through 12-in.

Fisher Governor Company.



Martin-Decker indicator-recorder for power tongs.

(10) Piston Pressure Switch. A Barksdale pressure switch, 9622 or C9622, is said to be capable of sensing two different pressures in one system and actuating independent electrical circuits at any two desired points.



Switch may be used to maintain a pressure where it is imperative that the system pressure does not exceed or fall below predetermined values. It is claimed to accurately sense any system pressure over an adjustable range of 15 to 3000 psi for proof pressures from 3000 to 7000 psi, depending on the switch setting.

Pressure settings are made by two external adjustment screws that can be locked in place to avoid accidental disturbance.

Barksdale Valves.

(11) Electronic-Hydraulic Control Unit. Ideal process conditions particularly important to the petroleum industry may be accurately maintained with the Swisstrol, an electronic-hydraulic control unit now manufactured by Swiss Colony.

Providing exact control with a minimum of equipment, the compact unit solves control problems involving pressure, vacuum, temperature, liquid level, flow, or condensate drainage.

Unit's speed of action is claimed to eliminate problems of "lag" and "hunting."

The Swiss Colony

(12) Vertical Force Magnetometer. Geophysical Instrument & Supply has available a vertical force magnetometer — for mineral exploration, such as mapping contacts, faults, etc., for location of magnetite and pyrrhotite, and for ground surveys in petroleum exploration. Sharpe A-Z is a one-man instrument, the orienting compass being permanently mounted on instrument. Sensitivity as fine as 10 gammas per scale division. Total weight, including tripod, is 13 lb.

Geophysical Instrument & Supply Company.

(13) Air-Actuated Governor Control. An air-actuated governor control for multiple engine drives which is claimed to throttle rods or mechanical linkage of any kind has been introduced by Stewart & Stevenson.

The new governor control system simplifies the synchronization of multiple engines and practically eliminates the possibility of an engine pulling more, or less, of its share of the load.

Stewart & Stevenson Services, Inc.

(14) Computing Telemetering System. A system of telemetering instruments which is designed to totalize several flow measurements, correct for such factors as temperature, pressure, specific gravity, and supercompressibility in fluids, and to provide a corrected flow value, has been announced by Bristol.

This system of telemetering transmitters and receivers, and electronic self-balancing instruments can be used whenever corrected flow values are vital for proper operation.

In a typical system, indicating or recording telemeter receivers retransmit the uncorrected flow values to a totalizing electronic instrument. At this stage, corrections for static pressure, temperature and specific gravity are made, either by signals from other Metameter transmitters or by manual settings, and the corrected total is recorded and integrated if desired.

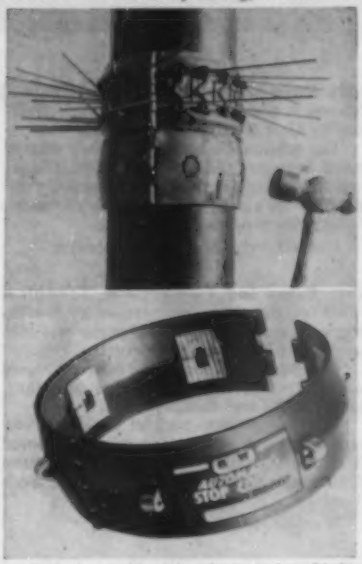
The Bristol Company.

(15) Oil Well Heating System. A package heater for use on wells to reduce paraffin deposition, aid in breaking emulsions and reduce viscosity has been introduced.

Designated the Clayton Model FG-8 Field Heater, unit is designed for permanent installation on the well for injection of heated oil at the bottom of the well. Unit operates automatically and handles continuous injection of hot oil for bottom hole heating up to 6000 ft in depth.

Oil Well Heating Systems, Inc.

(17) Automatic Stop Collar. B and W Automatic Stop Collars permit the mounting of scratchers and centralizers on high carbon and other alloy casing, where welding is not considered safe practice. Units are positioned on the casing joint and slips permanently set by hitting downward on the outer loop with a hammer until the loop is flush with the collar.



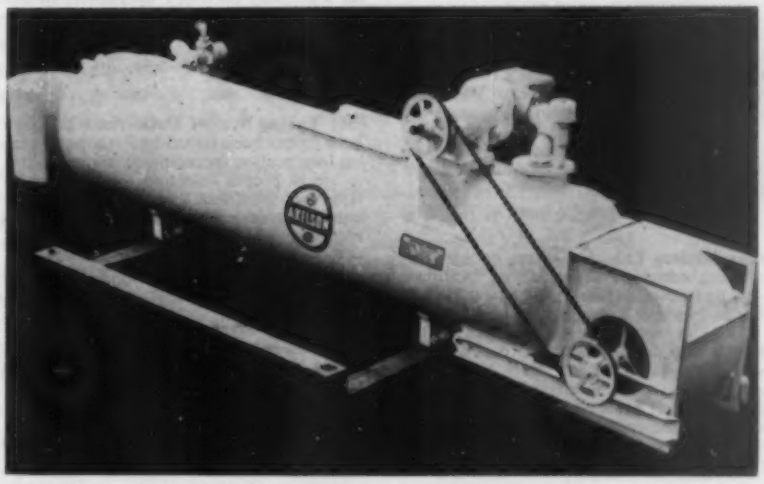
Device is supplied in solid collar form or hinged for installation on external upset casing.

B and W Inc.

(18) Slip-On End Caps. Protokap is now offering slip-over and roll-on end caps made of DuPont neoprene that are said to effectively seal out air, moisture, corrosive fumes, dust, and small animals.

Caps are designed to retard drying of thread dope and to keep the threads free of sand and grit.

Protokap, Inc.



(16) Ducted tanks for hydraulic pumping units. An air-cooled, ducted reservoir tank is now available for installation on Axelson hydraulic pumping units with 6-ft and 10-ft strokes.

In hot climates and under certain conditions where the temperature of the hydraulic oil would ordinarily be high, the Axelson Ducted Tank is a necessary accessory. When extreme heat conditions prevail, it prevents the breakdown of the oil and the overheating of precision components in hydraulic pumping units. The blower is used to force high-velocity air through and over the ducted tank, thus providing the maximum amount of cooling.

Axelson Manufacturing Company.

NEW Literature

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

(19) Fixed-Mounted Crane. Unit Crane & Shovel is now issuing new bulletins covering its Unit Mariner, Model 360.

The original bulletins previously offered have been revised to show safety factors which are considered to be extremely important for rating cranes which are specifically for stationary mounting.

Unit Crane & Shovel Corporation.

(20) Pump and Compressor Troubles. Two booklets have been issued by Worthington, one on diagnosing pump troubles and the other on compressor troubles.

The pump booklet tells how to locate and correct common ailments of rotary, centrifugal, and steam pumps.

The compressor booklet indicates how to locate and correct common air-cooled and water-cooled compressor troubles. Cartoon sequence pictures illustrate both booklets.

Worthington Corporation.

(21) Wire Rope Applications. A "Ropeology" bulletin has been released by Macwhyte.

The illustrated bulletin shows a new helicopter, a water well drilling operation, a sling lift, a water tower dismantling operation, several elevator installations and, in addition, various types of swaged fittings.

Macwhyte Company.

(22) Identifying Items. "Checks and Tags by Matthews" is a catalog now available from James H. Matthews.

This catalog is a combination of illustrative descriptive and technical data relating to metal checks, tags, plates, signs, badges and similar products for identifying items of all kinds.

James H. Matthews & Company.

(23) Single-Stage Torque Converter. A bulletin describing Twin Disc's 1500 Series Single-Stage Torque Converter, has been released by Twin Disc Clutch.

Illustrations and tables on the single-stage converter fluid circuit, horsepower and rpm capacity, and specifications are included in the bulletin.

Twin Disc Clutch Company.

(24) Nuclear Lab. A 10-page booklet describing company organization, facilities, and operation has been issued by Walter Kidde Nuclear Laboratories.

Booklet describes the company's research and development facilities at Garden City, Long Island, New York, and outlines the services offered by the company in such fields as reactor design, nuclear instrumentation, and experimental studies.

Walter Kidde Nuclear Laboratories, Inc.

(25) Coupling Selection. A coupling selection chart developed and issued by Morse Chain is said to reduce the time necessary to select a flexible coupling to a matter of minutes. The chart, 22 in. x 17 in., may be hung on the wall, inserted under a glass desk top, or folded for easy filing.

Morse Chain Company.

(26) Millivoltage Measuring Instruments. Concise information about Speedomax H electronic potentiometer-type indicators, recorders, and controllers calibrated directly in millivolts — −5 to 0 to +5 mv, 0 to 10 mv, or 0 to 50 mv — is now available in an illustrated two-page data sheet published by Leeds & Northrup.

This sheet presents a condensed tabulation of instrument characteristics for control applications ranging from simple two-position to full-proportioning control.

Leeds & Northup Company.

(27) Oil Conservation. A new publication, "Oil Conservation — A Vital Necessity," has been released by the Interstate Oil Compact Commission.

This two-color, 16-page pamphlet contains pictures of the governors of the member states of the commission and brief statements over their signatures concerning the necessity for oil and gas conservation, adequate state conservation laws, and the benefits derived from such laws in the individual states.

Interstate Oil Compact Commission.

(28) Tubing Spider and Slip Assembly. The National Type "B" tubing spider and slip assembly is presented by National Supply in an illustrated, four-page bulletin. Features of design and use are presented.

The National Supply Company.

(29) High-Rate Pressure Filter. Dorr-Oliver announces availability of a four-page, two-color bulletin on its Hi-Rate Pressure Filter.

Designed specifically for high-capacity water filtration with particular emphasis on secondary recovery operations in the oil fields, the Hi-Rate Pressure Filter is basically a leaf-type unit using some form of precoat material.

Dorr-Oliver, Inc.

(30) Tubing System Data. An eight-page booklet has been issued by Parker containing information including charts and tables to aid in proper selection of tubing as to size, wall thickness, and material for various operating conditions. Factors considered are flow requirements, pressures, severity of service, and temperatures.

The Parker Appliance Company.

(31) Bolted Steel Tanks. A 16-page brochure on bolted steel tanks has been published by Columbia Steel Tank. Brochure features a pictorial description of the use and application of synthetic gasket materials in the erection of bolted steel tanks.

Columbian Steel Tank Company.

(32) Well-Cementing. B and W has available an illustrated 10-page, two-color catalog containing complete descriptive, installation, and operation data on its line of primary cementing tools.

In addition, this catalog offers much information on how to obtain a better cementing job.

B and W, Inc.

(33) Chlorine Handling Equipment. Wallace & Tiernan has published new literature describing equipment used by industry for handling liquid and gaseous chlorine.

Literature illustrates and describes such chlorine handling equipment as: Liquid chlorine evaporators, valves and fittings for chlorine liquid and gas supply lines, manual and pilot-operated chlorine pressure-reducing valves, and chlorine gas metering equipment.

Wallace & Tiernan, Inc.

(34) Fracturing With Plain Water. Dowell has released a seven-page development bulletin on its fracturing service called "Riverfrac." The base material employed is unthickened fresh water, with or without graded sand. Bulletin includes the advantages of Riverfrac, characteristics of wells suitable for Riverfrac, and laboratory data.

Dowell, Inc.

(35) Recording and Controlling Instrumentation. "A new approach" to recording, indicating, and controlling instruments required in industrial processing is described in a four-page bulletin published by Fielden Instrument Division of Robertshaw-Fulton.

Bulletin tells of instrument systems featuring four basic components that can be interchanged to perform a variety of functions, as well as to minimize maintenance problems.

Fielden Instrument Division, Robertshaw-Fulton Controls Company.

(36) Drill-Blade Stabilizer. Grant Oil Tool has released a revised bulletin in Spanish on the Grant Drilblade Stabilizer. Bulletin describes the tool and its applications, with full specification details.

Grant Oil Tool Company.

(37) Generator Sets. Detroit Diesel Engine Division has issued a brochure outlining its complete line of electric generator sets.

Brochure includes specifications and illustrations of over 25 radiator and heat exchanger-cooled models ranging from 20 to 245 kw. Both 50 and 60-cycle and direct-current units for emergency standby and continuous off-the-line use are represented. Features of the two-cycle Detroit Diesel engines which operate the sets and automatic starting and shut-down equipment are fully covered.

Detroit Diesel Engine Division, General Motors Corporation.

(38) Rotary Swivels and Float Valves. An eight-page, two-color catalog describing its line of rotary swivels and float valves has been released by Gray Tool. Included in the illustrated pamphlet are features, specifications, and maintenance information.

Gray Tool Company.

(39) Bronze Globe Valves. A four-page three-color circular on the two pressure classes of Lukenheimer LQ600 Bronze Globe Valves, for a wide variety of services from normal to exceptionally severe, is now being offered by Lunkenheimer.

This circular describes the original Lunkenheimer Fig. LQ600-150 Valve, rated at 150 lb S.P., 300 lb W.O.G., and the new Lunkenheimer Fig. LQ600-200 Valve, rated at 200 lb S.P., 550F, 400 lb W.O.G. Both types are manufactured in eight different sizes, from ¼-in. through 2-in. diameters.

Lunkenheimer Company.

Buyers of Any Process Equipment
Reap Benefits from M. W. Kellogg's

COMMITTEE WORK

ANOTHER PLUS IN KELLOGG'S
BUILT-IN ENGINEER

As a leader in the design and fabrication of petroleum and petrochemical process equipment, The M. W. Kellogg Company assumes many extra curricular responsibilities which eventually benefit not only its customers but the process industries in general. One of these responsibilities is Kellogg's participation in technical committees of professional societies and associations, particularly at subcommittee working levels.

At present, M. W. Kellogg's engineers, metallurgists and others give a considerable part of their time to over seventy such activities . . . ranging from boiler and pressure piping codes to welding practices and radiographic testing techniques. Many of today's accepted design concepts were introduced to the engineering profession by Kellogg committee men.

The M. W. Kellogg Company is privileged to contribute increasingly to the important work of technical and engineering societies, associations, and related groups. The practical application of the knowledge imparted and gained is another plus which goes into Kellogg's "built-in engineer" approach to process equipment design and fabrication. A typical example is a paper prepared by M. W. Kellogg engineers, "Collection and Correlation of High Temperature Hydrogen Sulfide Corrosion Data," and presented at a recent meeting of the National Association of Corrosion Engineers. *Write for your copy.*

Fabricated Products Division

THE M. W. KELLOGG COMPANY, 711 THIRD AVENUE, NEW YORK 17, N. Y.

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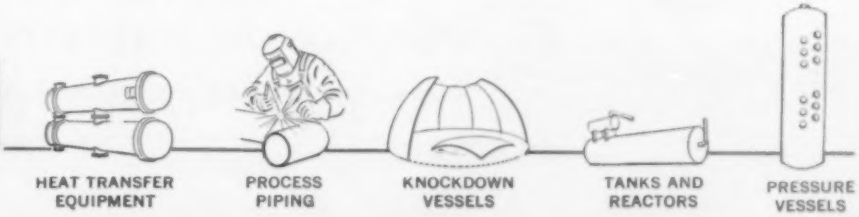
M KELLOGG W



New Copper Deactivator Guaranteed not to freeze!

This special all-weather UOP Copper Deactivator formulation will not freeze when stored for extended periods at temperatures down to 0° F. We call it Copper Deactivator-AW(50)*, since it contains active ingredient in 50% concentration. This new formulation completely eliminates the low temperature pumping problems common to other deactivators.

AW(50) gives maximum metal deactivating efficiency and economy. Improved color, too, and because of its better solubility and pumping properties, it can be injected directly into gasoline or other refinery streams without the customary dilution with aromatic spirits.

AW(50) is supplied in handy five-gallon containers for manual addition or blending with other additives and in 55-gallon drums for automatic injection systems.

*Trademark of Universal Oil Products Company

PRODUCTS DEPARTMENT

UOP

UNIVERSAL OIL PRODUCTS COMPANY

30 ALGONQUIN ROAD, DES PLAINES, ILLINOIS, U. S. A.

exclusive

the Refining Engineer

P 092.2

"Air Pollution"

What Causes Smog?

Greatest villain is automobile exhaust; refineries contribute very little, thanks to modern practices

What Remedies Have We?

Dr. W. L. Faith

Vice President and Chief Engineer, Air Pollution Foundation

THE role of hydrocarbons in the formation of smog is no longer a debatable question. All technical men now agree that hydrocarbons and related organic compounds are, together with oxides of nitrogen, the major cause of some, if not all, of the bothersome manifestations of smog. An emotional segment of the community, spurred on by rabble-rousers or sincere but uninformed individuals, yells: Get rid of them! Shut down the refineries! Abolish diesel trucks; Electrify the bus lines! Stop all traffic when weather conditions are favorable to smog!

A saner and fortunately larger group says: Certainly we must curtail the emission of air-polluting hydrocarbons and related organics, but let us not paralyze the community by ill-conceived panaceas that will kill the patient in an attempt to cure him. They then ask the logical question: How can this be done?

A review of the salient features of the hydrocarbon problem may help us formulate a solution. Ever since Col. Drake drilled the first producing oil well at Titusville, Pennsylvania, in 1859, and began to refine the crude oil (break it up into gasoline, kerosine, fuel oil, and other products) some hydrocarbons have escaped into the atmosphere. As demand for petroleum products grew and more low-boiling fractions (i.e., gasoline) were handled in manufacture, distribution, and use, more hydrocarbons were released into the air we breathe. In the sub-tropical restricted atmosphere of Los Angeles, these hydrocarbon vapors and other pollutants finally overtaxed the natural ventilation of the Basin and smog resulted. Obviously, this intolerable situation must be corrected. Since we can't improve our ventilation by reasonable means, we must choke the emissions at the source — or be choked ourselves!

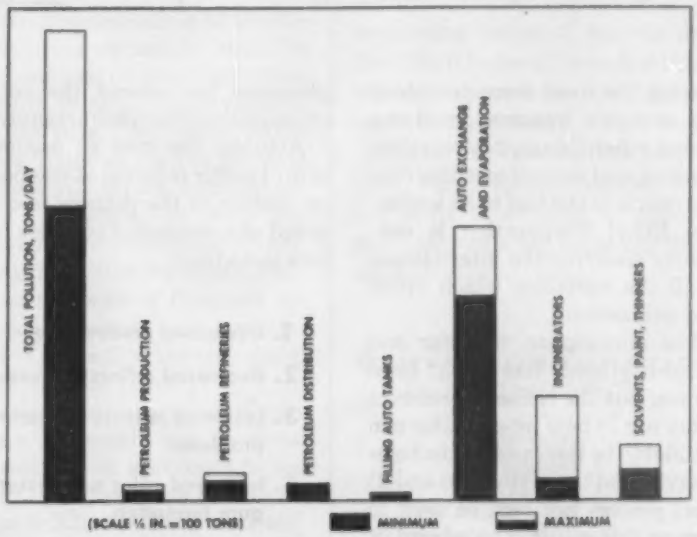
Three questions arise:

1. What are the sources of atmospheric hydrocarbons?
2. How much reduction is necessary to alleviate the resulting smog?
3. How may this be done?

What Are the Sources of Atmospheric Hydrocarbons?

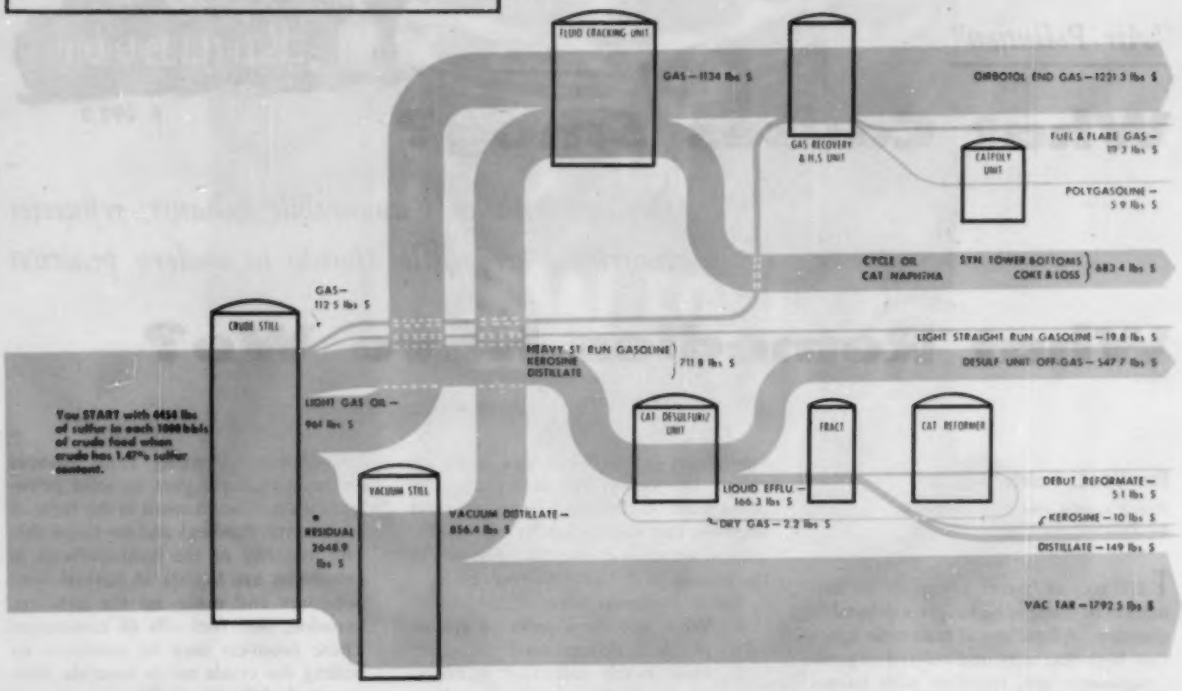
Practically all hydrocarbons originate in the ground as the mixture we call petroleum or crude oil. Petroleum is a mixture of thousands of different hydrocarbons, ranging from gaseous methane (natural gas) to solid petroleum waxes (best known in the form of ornamental candles) and tar (asphalt). The majority of the hydrocarbons in petroleum are liquids at normal temperatures and make up the gasoline, kerosine, and fuel oils of commerce. These products may be produced by boiling the crude oil to separate fractions of different boiling ranges. In 1921 a 42-gal barrel of typical California crude oil yielded 14 gal of gasoline by this simple distillation, which the petroleum technologist calls "topping."

In the early days of the petroleum industry the greatest demand was for kerosine, and even the small amount of gasoline concurrently produced was a nuisance to the refiner and was often



Graphs showing the relative and total amounts of pollutants discharged into the atmosphere daily from the different sources, minimum and maximum, in the Los Angeles Basin.

Where the Sulfur Goes


FLUID CRACKING UNIT
GAS – 1134 lbs S
GAS RECOVERY & H2S UNIT
ORTHOFOL END GAS – 1221.3 lbs S
FUEL & FLARE GAS – 19.3 lbs S
CAFFOLY UNIT
POLYGASOLINE – 5.9 lbs S
CYCLE OR CAT NAPHTHA
STM TOWER BOTTOMS COKE & LOSS } 683.4 lbs S
GAS – 112.5 lbs S
CRUDE STILL
You START with 6454 lbs of sulfur in each 1000 bbls of crude feed when crude has 1.47% sulfur content.
HEAVY ST RUN GASOLINE KEROSINE DISTILLATE } 711.8 lbs S
LIGHT STRAIGHT RUN GASOLINE – 19.8 lbs S
DESULF UNIT OFF-GAS – 547.7 lbs S
LIGHT GAS OIL – 961 lbs S
CAT DESULFURIZ UNIT
FRACT
CAT REFORMER
VACUUM STILL
VACUUM DISTILLATE – 856.6 lbs S
RESIDUAL 2648.9 lbs S
LIQUID EFFLU – 166.3 lbs S
DRY GAS – 2.2 lbs S
DEBUT REFORMATE – 5.1 lbs S
KEROSINE – 10 lbs S
DISTILLATE – 149 lbs S
VAC TAR – 1792.5 lbs S

How to save up to 7¢ per barrel on lead

Ethyl Research studies show you can increase the octane number by decreasing the sulfur . . . and use less lead!

Getting the most from your lead is a complex business involving among other things, hydrocarbon blending and control of sulfur concentration in the fuel to be leaded. The Ethyl Corporation is constantly studying the interrelation of all the variables which affect lead utilization.

The antagonism of sulfur and tetraethyllead has long been known, but the refiner's problems today are 1) how much sulfur can justifiably be removed on the basis of savings in tetraethyllead and 2) what process can best be used to remove this sulfur. The advent of large volumes of high-pressure hydrogen at relatively low cost as a by-product of catalytic reforming processes has altered the entire economic picture of sulfur removal.

Actually the over-all justification of sulfur removal at one point or another in the refinery is composed of a number of complex factors including:

1. **Decreased product odor**
2. **Decreased refinery corrosion**
3. **Lessened refinery operating problems**
4. **Improved color and lessened gum formation**
5. **Improved tetraethyllead response**
6. **Sale of recovered sulfur**
7. **Avoidance of catalyst poisoning**
8. **Improvement in lube-oil life in the engine**

Of these various factors, perhaps the easiest to assign dollars-and-cents justification to (and certainly the one with most widespread application) is a saving in tetraethyllead.

Figure 1 shows the effect of the type of sulfur compound on Research octane number loss. This plot is based on U.S. pool gasoline which has a 79.2 Research octane number clear and a 92.0 Research octane number with 3 cc. of lead, and which contains 0.075 per cent total sulfur which may take the

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

form of the various compounds shown below.

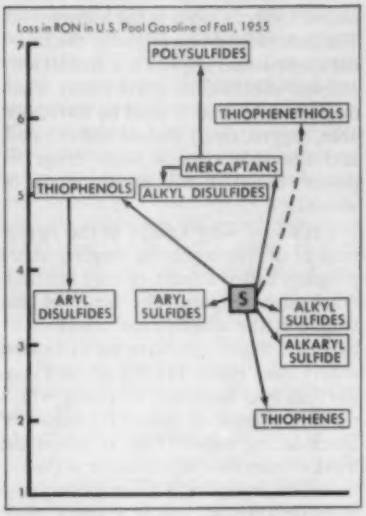


Fig. 1. *Effect of type of sulfur compound on RON loss*

Actually, a reasonable assumption would be that gasoline contains half monosulfide sulfur and half thiophenic sulfur. Complete removal of this sulfur, although economically attractive, is a practical impossibility. With the advent of hydrogen treating, however, there is no reason why 50% sulfur removal cannot become a reality. Figure 2 illustrates the TEL savings which are possible with 100%, 75% and 50% sulfur removal from U.S. pool gasoline of 91 RON with 2.38 ml. of TEL.

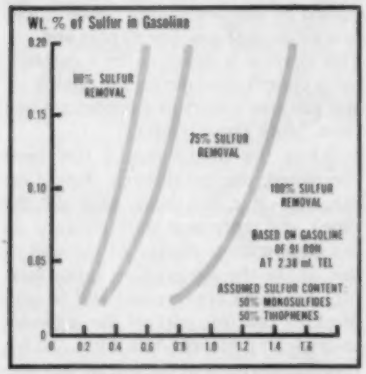

Wt. % of Sulfur in Gasoline
100% SULFUR REMOVAL
75% SULFUR REMOVAL
100% SULFUR REMOVAL
BASED ON GASOLINE OF 91 RON AT 2.38 ml. TEL
ASSUMED SULFUR CONTENT 50% MONOSULFIDES 50% THIOPHENES

Fig. 2. *TEL savings (ml. per gal.) with sulfur removal*

The average refiner, while he may be interested in the above data, still wants to know, "What's in it for me?" and Figure 3 answers this question. Here the possible savings in cents per barrel of gasoline are shown as a function of the weight per cent sulfur in the gasoline pool. This relationship is independent of the lead susceptibility of the particular stock and of the Research octane number level. Here, again, we are assuming half monosulfide sulfur and half thiophenic sulfur, and the economics of 50 and 75 per cent sulfur removal are shown for TEL levels of 1.5 and 3.0 ml/gallon.

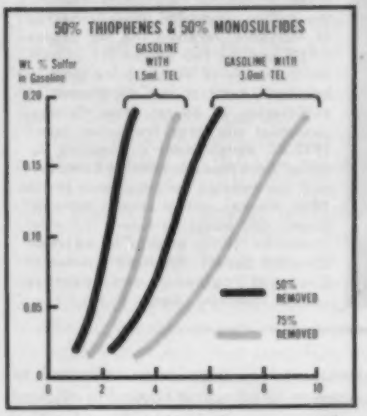


Fig. 3. *¢ per bbl. savings possible*

For example, it can readily be seen that a pool gasoline requiring 3 ml/gal of TEL and containing 0.10% sulfur could meet the same octane specifications with a saving in TEL cost of 7 cents per barrel if 75% of the sulfur were removed.

It is not unreasonable to assume that pool octane number could be raised one unit by desulfurization. Current octane-improvement costs, as shown by recent Ethyl studies, range as high as 16 cents per Research octane number per barrel. Therefore, 16 cents per barrel could be considered a justifiable expenditure for desulfurization on the basis of Research octane quality alone. Your justification will depend on the conditions specific to your refinery.

The optimum operation of your refinery to permit you to make the most of your lead could be the subject of a profitable discussion with your Ethyl refinery technologist. Your Ethyl Representative will be glad to arrange an appointment for you.

What Ethyl Research offers you

At today's high octane level, the advantages of getting more efficiency from your lead have taken on more and more importance. To complement the intensive effort which the industry is devoting to this problem, Ethyl Research is continuously studying how the hydrocarbon blending and sulfur removal factors can lower lead requirements.

We are constantly testing and probing all the variables which affect lead utilization in today's high-compression engines. The problem of sulfur removal and the sudden entrance of high-pressure hydrogen, as a by-product of catalytic reforming, into the economic picture is being watched very carefully at Ethyl Research. Write to Ethyl Corporation, Box 12, for a copy of "Sulfur in Gasoline—an Economic Appraisal"—another in the continuing series of reports from the Ethyl Corporation on fuel blending and other studies of vital interest to refiners today.

For further information, just call your Ethyl Representative. He'll be happy to arrange an appointment for you with one of our Technical Representatives.

ETHYL CORPORATION
New York 17, N.Y.

Research Laboratories:
1600 W. Eight Mile Road, Ferndale 20, Michigan
2600 Cajon Road, San Bernardino, California

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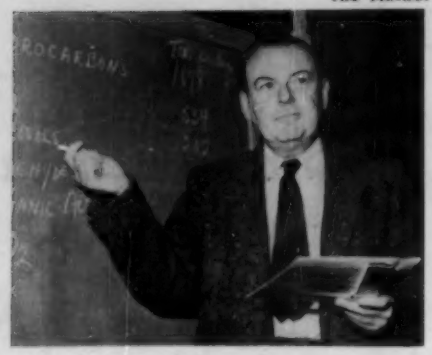
The Author



Presently vice president and chief engineer of the Air Pollution Foundation, the author graduated from University of Maryland, received the MS degree (1929) and the PhD degree (1932) from the University of Illinois. Since then he has been head of the department of engineering of Kansas State College; consultant with War Production Board 1942-45; development engineering director, Corn Products Refining Company, and was selected for his present job in 1954. He has written several technical papers and books, including *Industrial Chemicals* (1950); belongs to American Chemical Society, American Institute of Chemical Engineers, and honorary science fraternity, Sigma Xi.

wasted. When the automobile became popular, simple boiling (distillation) of crude oil could not furnish sufficient gasoline to meet the demand. Brilliant scientists, such as Dubbs, Cross, and Burton, found that by heating the crude under pressure some of the "heavier" (higher boiling) hydrocarbons would break down into hydrocarbons in the gasoline boiling range, and that subsequent distillation could produce 35 gal of gasoline per barrel of crude oil. The product was "thermally cracked" gasoline.

Demand for even more and higher-quality gasoline led to a whole gamut of peculiarly named processes, such as catalytic cracking, alkylation, hydroforming, polymerization, and the like. Today the yield of gasoline is in excess of 45 gal per barrel of crude. Without these tailor-made gasolines no airplane would leave the ground and today's powerful automobiles would lope along like wounded steers.

In all phases of these operations some hydrocarbon losses occur by evaporation into the atmosphere. There are losses at the well, from crude-oil storage tanks, intermediate storage tanks, and product storage tanks. Some hydrocarbons are lost by pump leakage, from valve stems, from skimming ponds, separators, processing units, and by accidental spills.

In Los Angeles County these losses have been of considerable concern to the Air Pollution Control District, to the petroleum refining industry, and to the public. By virtue of Control District regulations and industry's expressed desire "to be a good citizen of the community," these losses have been the target of a continuing battle, which has involved an expenditure in excess of $30,000,000.

Floating roofs (to reduce evaporation) have been placed on storage tanks, skimming ponds have been covered or virtually eliminated, separators have been covered, pumps and valve stems have been tightened, and incidental vapors have been collected in common headers and burned in efficient combustion units. Vapors from loading racks have been collected and recovered, or burned in plant boilers. As a result, hydrocarbon losses in refineries have been cut to a "nearly irreducible minimum" of 90 to 120 tons per day.* Losses from producing fields in the area are estimated at an additional 30 to 40 tons per day.

So much for the manufacture of gasoline and other losses in refinery areas. The next area in which losses occur is in the distribution of gasoline outside the refinery gates. These are chiefly evaporation losses from tanks at bulk terminals and the loading and unloading of trucks and railroad cars. Total evaporation losses during marketing, including the filling of service station tanks, are estimated to be 55 to 60 tons per day.

At the 6600 filling stations in the area, another 25 tons per day are lost in transferring gasoline to automobile tanks. Some work is under way to develop recovery facilities to reduce these losses, but no economically acceptable device is yet available.

Thus, hydrocarbon losses during the production, refining, and marketing of petroleum products may be summarized as follows:

	Hydrocarbon Losses (tons per day)
Production	30 to 40
Refining	90 to 120
Distribution	55 to 60
Filling auto tanks	25
Total	200 to 245

Although this quantity of hydrocarbons is equivalent to more than 50,000 gal of gasoline daily, it is only a minor portion of the total organic material entering the Los Angeles atmosphere.

The other major source of atmospheric hydrocarbons is the automobile. The automotive power plant, the internal-combustion engine, is a remarkably efficient mechanism, particularly when one considers that it must be transportable, rugged, easily started and stopped, and operable over a wide range of power requirements in all kinds of weather.

Let's look very briefly at the operation of this automobile engine, more properly called a spark-ignited internal-combustion engine. The heart of this engine is the combustion chamber or cylinder. Some cars have six cylinders; others have eight. The top of the cylinder has two openings or ports, which may be opened or closed by means of quick-acting valves. One is called the intake (inlet) valve; the other is the exhaust (outlet) valve. Also extending into cylinder through top is a spark plug.

The bottom of the cylinder is a movable piston that pumps up and down. At the uppermost point of the piston stroke there is still a small space between the piston head (the movable bottom of the cylinder) and the top of the cylinder, or cylinder head, in which the two valve ports and spark plug are located.

Let us follow the movement of the piston head through its 4-stroke cycle, beginning with its topmost position. As the piston descends (the intake stroke), the intake valve opens and the suction caused by the descending piston draws in a mixture of gasoline vapors and air. This mixture is delivered by a carburetor, a complicated device for mixing air and gasoline vapors in a predetermined ratio. More about it later.

When the intake stroke has been completed, the intake valve shuts (the exhaust valve has been shut all the time) and the piston starts upward on the compression stroke. At the end of this stroke the air-gasoline vapor mixture has been compressed and is confined to the top part of the cylinder under high pressure. At a point just before the piston is at the top of this second or compression stroke, a spark ignites the compressed mixture. As the air-gasoline mixture burns (all this takes place in a fraction of a second, so it's really a controlled explosion) it increases in volume due to the chemical reaction that takes place and also the heat evolved. The volume increase drives the piston down again (the power stroke) to the bottom of its travel. Because the piston is connected to the crankshaft, and ultimately to the driveshaft, it is this surge of power that propels the car.

As the piston starts back up again

*Ranges are shown where estimates of various groups or agencies differ. The higher estimate was made by the Control District; the lower one by the Western Oil and Gas Association. The range probably represents actual losses more accurately than does any single value.

(the exhaust stroke) the exhaust valve opens and the spent gases are forced into the exhaust system and eventually out the tailpipe of the car. The exhaust valve closes, the intake valve opens, and the 4-stroke cycle begins again. Each upward and downward stroke of the piston constitutes one revolution of the crankshaft. Under idling conditions most current models of automobiles operate at 450 to 500 rpm (revolutions per minute); under accelerating and cruising conditions the speed may reach 4000 rpm. At the latter speed, in each cylinder there are 4000 upward and downward piston strokes and 2000 explosions each minute.

Now let us look at the composition of the gases leaving the tailpipe. If sufficient air is present in the combustion chamber when the mixture is ignited, and if sufficient time is allowed in the cylinder for the burning to be completed, and if the mixture in the cylinders is sufficient to keep air in contact with unburned fuel until burning is complete, *then* the exhaust would consist entirely of harmless carbon dioxide and water vapor.

Three "ifs" are in the preceding statement and none of them have been entirely overcome in practical engines. The main reason is this. At idle we need only sufficient fuel and air to keep the engine operating; when we accelerate we need maximum power (much more fuel) to move a 2000 to 3000-pound car quickly from a standstill to the desired speed; at cruise the power requirement is less, but also steady, hence more efficient; under deceleration no fuel is required. On the other hand, as we go from deceleration to idle, fuel must be supplied quickly enough to keep the engine from stalling or operating roughly at the changeover.

It is, of course, easier for the automotive engineer to design an engine to operate efficiently in any one phase of the cycle than to give high efficiency for all four phases and the intermediate steps between them. Because of these factors (and several others not mentioned) engine design represents a compromise that will result in the best over all operation of the automobile. To accomplish this compromise, more fuel must be supplied to the cylinder than can be completely burned by the air supply. Accordingly, some unburned gasoline (hydrocarbons) and some partially burned gasoline (other organic compounds and carbon monoxide) are present in the exhaust gases. In an average situation, these losses are estimated at 5 to 7 per cent of the fuel supplied.

Since approximately 5,000,000 gal of gasoline are consumed daily in the Los Angeles area by automobiles, buses, and trucks, this loss represents 250,000 to 350,000 gal or 775 to 1100 tons per day of hydrocarbons. In addition, evaporative losses from carburetors and gasoline tanks are estimated at 10 gal per car per year, which is equivalent to 200 tons per day in the Los Angeles Basin. A rough estimate of the total hydrocarbon loss from automobiles is then 975 to 1300 tons per day.

The Control District's estimate (by another method) is 1090 tons per day, which is in the range shown. It is obvious that only a *range* of values can be given because of the great variation in emissions from one car to another, the even wider variation in individual driving habits, and some variation in the number of cars in operation on a given day. A further complication arises because scientists don't know the accuracy of their methods of analyzing exhaust gases for hydrocarbons.

Several other miscellaneous sources of hydrocarbons and related organic compounds in the air should be mentioned. These are diesel engines, incinerators, evaporation of paint-thinners, and handling of solvents in the process industries. A quick review of the estimates of these sources shows:

	Organic Emissions (tons per day)
Diesel engines	1 to 20
Incinerators	80 to 480
Paint-thinners	up to 200
Solvent handling	up to 50

The degree of certainty of any of these figures is much less even than that for automobiles.

A recapitulation of the total hydrocarbon and related organic chemical emissions to the atmosphere, as discussed previously, shows:

Source	Amount (tons per day)	% of Total
Petroleum production	30 to 40	1.3 to 2.8
Petroleum refineries	90 to 120	4.0 to 8.4
Petroleum distribution	55 to 60	2.4 to 4.3
Filling auto tanks	25	1.1 to 1.8
Auto exhaust and evaporation	975 to 1300	50.0 to 75.1
Incinerators	80 to 480	4.3 to 26.6
Solvents and paint-thinners	150 to 250	6.9 to 16.6
	1405 to 2275	100

How Much Hydrocarbon Reduction Is Necessary to Alleviate Smog?

From time to time various investigators have estimated the percentage of hydrocarbon reduction necessary to eliminate smog. Most of these estimates have been based on two assumptions: (1) That single-chamber incinerators would be abolished by October 1, 1957, and (2) that further reduction in emissions from petroleum production, processing, and handling will be of comparatively minor proportions. The remaining sizeable decrease in hydrocarbons must then come from the automobile, which puts out the largest quantity. Estimates of the required reduction of hydrocarbons from automobiles range from 60 to 90 per cent. The lower figure is based on present emissions; the higher one takes into consideration the continued growth of the community, with perhaps twice as many cars on the road in 10 to 20 years and a consequent increase in total emissions.

There is a mounting suspicion, however, that even 90 per cent reduction of hydrocarbons in auto exhaust may be insufficient unless a concurrent reduction in nitrogen oxides is accomplished. On the other hand, with sufficient reduction of nitrogen oxides, the required reduction in hydrocarbons may not be so great.

To obtain a more exact idea of the required amount of reduction of both pollutants and the relationship between the two, the Air Pollution Foundation has set up experimental smog chambers at two locations to study the problem. These studies currently are aimed only at the eye irritation manifestations of smog. Whether results will also be applicable to vegetation damage and visibility reduction is problematical.

How May Necessary Hydrocarbon Reduction Be Accomplished?

A study of means of reducing hydrocarbons in auto exhaust is going forward on several fronts. Industry, government, and private research laboratories have stepped up control-device development in the past two years. Two approaches to the problem have been suggested. They are:

1. Improve combustion efficiency of the engine.
2. Remove the hydrocarbons from the exhaust system before they are released to the atmosphere.

The two approaches may be likened to prevention and cure, respectively.

Before combustion efficiency can be improved it is necessary to know how present efficiency varies with the operating cycle of the automobile. Studies have been made by the Control District, by industry, and by private research or-

ganizations. These studies indicate:

1. The greatest quantity of hydrocarbons is emitted during deceleration. Analyses of exhaust for hydrocarbons during deceleration have yielded a wide range of values, from 2000 ppm (0.2 per cent) to more than 20,000 ppm (2 per cent). If we assume a typical Los Angeles driving pattern to be 46 per cent of the time spent in cruising, 18 per cent in idling, 18 per cent in acceleration, and 18 per cent in deceleration, and if we use the District's analysis of the exhaust of a 1951 automobile (deceleration — 5125 ppm hydrocarbons; idling — 1275 ppm; acceleration — 410 ppm; and cruising — 354 ppm), we can calculate 63 per cent of the hydrocarbons reaching the air is evolved during deceleration. Recent estimates made by the automobile industry (based on a 50-car survey in Los Angeles) indicate this value may be as low as 25 per cent. A more complete study is under way.

2. By use of the District's figures, one can show that emissions during the other phases of the cycle are: Idling — 17 per cent; cruising — 13 per cent; acceleration —7 per cent. The quantity of hydrocarbons leaving during deceleration can be related to the degree of vacuum in the cylinders at this stage of the cycle. The combustion chamber is designed to burn the fuel when the gasoline is under pressure in the chamber, so it is not surprising that poor combustion is found under vacuum.

To understand how a vacuum is produced during deceleration, let us look at engine characteristics during this period. Since the throttle is closed, no gasoline is fed to the cylinders, but the pistons continue to pump up and down very rapidly because they are connected to the rotating crankshaft. During the intake stroke a high degree of suction is developed. Because of the way carburetors are designed, gasoline vapors are sucked into the cylinders from the open idling jet. Furthermore, because of the high vacuum, the fuel burns imperfectly and is largely exhausted in an unburned condition.

It is obvious then that we might correct this condition either by closing off the idling jet or by relieving the vacuum, or both. This is easier said than done because when we approach the idling condition, i.e., stop, we need a gasoline-air mixture quickly (almost instantaneously) to keep the engine from stalling. Theoretically, a fuel-cutoff device might reduce hydrocarbon emissions by 63 per cent, if this is the correct figure. If the device were only 80 per cent effective, the reduction would still be: 0.80×63 per cent = 50.4 per cent. But hydrocarbons could be still further reduced by a vacuum breaker that would supply air to burn some of the fuel still finding its way into the cylinder. These are the reasons why the auto industry and others are trying to develop suitable fuel-cutoff devices and vacuum breakers, or a combination of the two.

We must not forget, however, that the assumed 63 per cent value we developed needs to be further substantiated. If a car is operated less than 18 per cent of the time on deceleration, or the average emissions from all cars during deceleration are less than the analysis given, the over all reduction would be much less. It is not too farfetched to assume that the percentage emissions during deceleration is only 25 per cent, in which case a combination fuel cutoff and vacuum breaker of 80 per cent efficiency would reduce hydrocarbons emitted to the air by only 0.80×25 per cent, or 20 per cent. Accordingly, the total amount of emissions must be accurately checked on many cars, and a more nearly accurate driving pattern must be obtained. The automobile industry is currently working on these two problems.

The problem during idling is a little more clear-cut. It has been found that minimum emissions during idling may be obtained only when the proper air/fuel ratio is maintained. This calls for good maintenance of the carburetor and setting the carburetor to deliver the proper air/fuel mixture during idling. This ratio varies from one engine design to another, but at the proper ratio only 2 to 4 per cent of the fuel goes through the combustion chamber unburned. Further reduction can be attained only by basic changes in automobile design, which is 10 to 20 years away according to best estimates.

Reduction of emissions during acceleration and cruising is less obvious, although some believe that fuel injection directly into the combustion chamber, rather than from a carburetor delivering gasoline through a manifold, may be helpful.

Before leaving the discussion of fuel-cutoff devices and vacuum limiters, a word about costs would be appropriate. Accurate costs are not available because a perfected device is not yet on the market. A simple vacuum limiter in the form of a dash-pot (throttle retarder) might cost only $5; a more complex fuel-cutoff unit might be as much as $40. Generally, estimates run between $10 and $25.

The other approach to hydrocarbon reduction centers around the exhaust system of the automobile. If we assume we can't keep some gasoline from leaving the cylinders unburned or only partially burned, we might install a unit in the exhaust system to complete the burning so that the only emissions would be harmless carbon dioxide and water.

Two such devices have been proposed, the afterburner and the catalytic converter. A simple afterburner would be a large chamber, perhaps the muffler, into which extra air for the complete burning of hydrocarbon vapors would be admitted. We then would need a means of igniting the mixture, and sufficient volume to allow the gases to burn completely.

A satisfactory afterburner will have fairly rigid requirements. It must be so designed that the proper amount of air to complete the burning is available at all times. Too little would not allow complete burning; too much would lower the temperature and consequently prevent complete burning. The difficulty of admitting the proper amount of air lies in the wide variation in hydrocarbon content at different phases of the operating cycle. Further, the flame must be confined to the burner and not shoot out the tailpipe. To accomplish this a large chamber is required — and there isn't room under modern cars for anything much larger than conventional mufflers. Currently, the only satisfactory afterburner is adaptable only to trucks and busses because of its size. Its cost has been estimated at $175 to $200.

Catalytic converters operate on a principle similar to afterburners, but require less space. Burning is accomplished on a metal-like surface (catalyst) in a manner similar to that of some self-igniting cigarette lighters. Among the several problems that must yet be solved are low-temperature initiation of burning, poisoning of the catalyst, and life of the catalyst. If one has to operate the auto for 10 minutes before the burner "catches," a considerable amount of hydrocarbons may escape. Catalyst poisoning (rapid loss of efficiency) is caused by the lead content of gasoline, without which modern engines would "knock." Catalyst life (the period of acceptable efficiency) must be such that replacement oftener than every 6 months would not be required. Otherwise, operating costs might be unacceptable to the public. There are other technical problems that bother automotive engineers, but they will not be discussed here.

Both afterburners and catalytic converters will be more expensive than carburetor devices, but they may also be more effective and less dependent on engine maintenance. Cost estimates have run all the way from $25 to $250, but the eventual cost will depend upon how efficient the units must be and whether their design can be standardized. ★ ★ ★

EXCLUSIVE

FIG. 1. **Main effluent from the refinery,** the dam and spillway controlling this water. Thousands of gallons of waste water per minute are returned to the river through this spillway. The flow is nearly 1/200 of the total flow of the Mississippi at low water periods. Care must be exercised to see that harmful chemicals are not allowed to flow out this spillway. The dam forms the large master separator, which has reduced stream pollution about 70 per cent.

P 092.2

Air, Water Pollution

Goldfish Are Good Sanitary Inspectors

Anti-pollution measures are many at Esso's Baton Rouge Refinery

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and
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PROGRESS over the past 10 years in the field of air and water pollution control at the Baton Rouge, Louisiana, refinery has resulted from an active interest in this problem by administrative, technical, process, and mechanical departments together with the establishment of a separate department to coordinate and control air and water pollution and refinery losses. Large expenditures have been made to realize sizable reductions in air and water contaminants being discharged to the atmosphere and to the receiving waters.

At the start of the program on air and water pollution abatement, the services of outside consultants were obtained to make overall surveys of each of these phases of pollution. As a result of recommendations made by the consultants on water pollution control, a small department was set up in the refinery to operate the separators, the emulsion treating units, and the main sewer system, to direct the activities of loss inspectors, and to coordinate tank cleaning work. Since these activities were usually related to refinery losses, the coordination of refinery loss work and the verification and checking of bulk delivery quantities were later added to the responsibilities of this department. Daily visual checks of air contamination and participation in the air analyses program were also included in the work.

Upper management has taken a keen interest in the problem of pollution at the Baton Rouge refinery and has allowed engineering and other scientific personnel to spend as much time as needed to maintain good conditions.

FIG. 2. **Silt treating unit** is the first of its kind ever built. The oil-laden silt and mud containing almost 25 per cent oil is pumped into these large cone-bottom tanks. Water and air are added, the silt is washed and about 90 per cent of the oil removed and returned to process. About 90,000 cu yd of silt per year are processed by these units.

The head of the department primarily responsible for these activities is an engineer while the assistant head is a chemist. In addition, scientific personnel in other technical and engineering groups are assigned to the problem as needed.

Water Pollution

In starting more active control of water pollution, it was recognized that efficient separator operation was only possible if the materials entering the separators were controlled. As a result, a survey was made of the objectionable materials entering the separators and means found to keep them within reasonable limits.

One of the first things that was done was to install a system of lines to accumulate most of the spent caustics and emulsifying agents from process operations in a 20,000 bbl tank. The tank was equipped with a swing suction so that oil accumulating on the surface could be pumped back to process. The spent caustic was used in emulsion treating operations and was then released to an earthen pit from which it was discharged at a constant rate downstream from the primary separators, thus eliminating the possibility of causing emulsification in the primary separators. This also prevented large surges of chemicals in the refinery effluent.

An emulsion treating unit was constructed to treat all emulsions recovered from the separators and other sources, to less than 1 per cent BS&W prior to being returned to process. All emulsions are treated currently to obtain maximum efficiency of tank settling capacity. The emulsion treating unit consists of the necessary pumps, two heaters, and an orifice mixer. The emulsion is pumped through the heater while the chemicals are being injected, thoroughly mixed and discharged into settling tanks. Approximately 165,000 bbl of tankage are available for treating and handling emulsions and slop oil. All this tankage is equipped with open-steam and vertical-closed coils, with sample cocks at 2-ft intervals and swing suctions for removal of clean oil. *Approximately 2500 bbl per day of oil are recovered from this unit.*

In order to treat the difficult emulsions usually found in tank bottoms, lines have been installed over the years to most refinery tanks so that the BS&W can be pumped to two 30,000-bbl tanks. These lines are also used when tanks are cleaned. In this operation, the bottom sediment is washed out of the tank with fire hoses and pumped to the two slop tanks. These tanks are heated to about 180F, and the water drawn off. The remaining emulsions, together with separator emulsions, are treated in the emulsion treating unit with waste soda or commercial demulsifying agents to recover all available oil.

The high turbidity of Mississippi River water results in appreciable quantities of solids, together with entrained oil, settling in the separators. To prevent the possibility of pollution resulting from this material being discharged to the river, a silt treating unit was built to remove the free oil from the silt. Here the silt is washed in three 4500-bbl, cone-bottom tanks by aerating, settling, and skimming the oil off the top. Approximately 90,000 cu yd of silt are treated yearly by this process with an oil recovery of approximately 95 bbl per day.

Automatic inlet skimmers have been installed on all separators to reduce the quantity of oil discharged to the main body of the separators. Flow recorders installed on the discharge of these skimmers give the separator operator an immediate indication of excess oil entering the system. A 2000-gal tank wagon equipped with a sludge pump is also available for picking up oil spills throughout the refinery. Dempster dumpster boxes are available for picking up solid and semisolid hydrocarbons. These latter materials, together with drummed oil and waste asphalt, are dumped into a melting tank, mixed with slop oil and pumped into the slop oil tankage, where they are treated and returned to process.

As a further control on separator operations, three inspectors make daily checks of the sewer system to determine the source of oil entering the system

About the Authors

Jarvis E. Miller has been with Esso Standard Oil Company since 1929. He has been connected with the company's high-pressure hydrogenation work for many years, and since 1945 has been head of the Oil Conservation division at Esso's Baton Rouge, La., refinery. He received his master's degree from the University of Texas and took his Ph D in chemical engineering at the University of Michigan in 1930.

G. F. Ullrich has been with Esso Standard Oil Company at its refinery in Baton Rouge, La., since 1938, when he completed a BS degree in chemistry at Loyola College of the South. Since 1944, he has been engaged in technical service and operational work in pollution control, and presently serves as assistant head of the plant's Oil Conservation division.

and develop with operating departments methods of eliminating these discharges. **As a result of these activities, the quantity of oil discharged to the sewer system has been reduced from 2.14 per cent on the refinery crude run in 1945 to 0.58 per cent in 1955.**

Master Separator

To further improve the quality of the refinery effluent, a large earthern master separator was built to furnish additional settling time and greater protection against emergency losses into the river. This separator is 20 ft deep, 300 ft wide, and 800 ft long. A suction-type dredge is operated in this separator on a daily basis to remove the silt deposited from the muddy Mississippi River water, which is the water principally used for refinery operations. Careful attention is given to the effluent, which averages about 14 ppm total oil content. Samples are composited by an automatic sampler and run daily for oil content, pH, and weekly for phenol content. Spot samples are checked monthly for B.O.D., dissolved oxygen, and chemical composition.

Two 40-gal aquariums are maintained where the refinery effluent enters the river. Gold fish are kept in both aquariums as indicators of pollution. One aquarium is constantly fed river water while the other is constantly fed a mixture of refinery effluent and river water 10 times the highest ratio of refinery effluent ever found in the river. The fact that the gold fish thrive equally well in both aquariums is an indication that the river is not being harmed by the effluent. Gold fish are used because they are easier to see in the turbid river water and have been demonstrated to be reliable test animals.

A consistent program of posters, memorandums, and formal training has been maintained for the last few years to keep all employees loss and pollution conscious. Posters are distributed each month, and each six months each supervisor receives a personal copy of a poster that shows the progress made during the period as compared with the preceding period.

Air Pollution

Smoke abatement. As recommended by the outside consultants on air pollution, control was first focused on the problem of smoke abatement. A careful review made of materials that were being sent to the refinery burning pit revealed that large quantities of recoverable oil, asphalt, wax, etc. were being disposed of by burning. This resulted in the release of heavy black smoke to the atmosphere. A careful check was instituted of the materials sent to the burning pit, and where possible they were diverted to the recovery unit. Here they are melted into slop oil and sent to the emulsion treating unit for treatment before being returned to process. Careful control of the materials allowed to be sent to the burning pit resulted in considerable reductions in smoke to the air.

The refinery flare stacks were another source of smoke. To reduce this source, meters were installed to measure the quantity of gas being burned at the various flare stacks, and these figures were utilized as justification for recovery facilities and as a means of persuading operating personnel to reduce the quantity of gas flared. In addition, facilities were installed on the larger flares to inject steam at the top of the flare. The steam is controlled by the gas meter in a ratio sufficient to eliminate most of the smoke and to reduce the luminosity of the flame.

Hydrogen sulfide removed from naphtha streams was being discharged to the flare stacks where it was usually converted to sulfur dioxide, but on occasion the flare would go out and people would complain of the odor downstream from the stack. This hydrogen sulfide stream is now sold to an adjacent chemical company, where it is converted to sulfur for use in sulfuric acid production. Approximately 25 tons per day of hydrogen sulfide are now converted to sulfur by this method, with resultant removal of this material from the atmosphere.

Sulfur dioxide and other odors associated with acid separation and acid concentration have also been greatly reduced. This was accomplished in some cases by shipping the spent acids and tars to a local chemical company, where the acid is burned and converted to 98 per cent sulfuric acid. In other cases, water wash towers have been installed on agitators and on tank car racks used for sulfuric acid loading. The water removes most of the objectional odors and materials originating from these operations.

Considerable reductions have also been made in the quantity of hydrocarbons released to the atmosphere. As a result of a tank repair program started in 1948, hydrocarbon losses to the atmosphere from this source have been reduced approximately 60 per cent, or from 0.52 per cent of the crude divisor to 0.20 per cent of crude divisor. This program included the installation of floating roofs on most of the gasoline and naphtha tanks and many crude tanks in addition to the complete repair of all cone-roof tanks to assure gas tightness. Painting of all volatile tanks white and the installation of conservation vents were also included in this program. Losses of hydrocarbons to the

FIG. 3. **Master separator for final clean-up of effluent.** Oil retaining wall of the master separator is in the background. The dredge removes silt.

FIG. 4. **Tank wagon and pumping equipment** used for picking up oil spills throughout the refinery.

FIG. 5. **Inspector checks the sewer system** for excess oil discharge in presence of unit operators.

atmosphere have also been reduced as a result of the separator inlet skimmers mentioned above and by better pump maintenance and extensive use of mechanical seals.

Policing to Prevent Air Pollution

Inspection of atmosphere. In order to maintain adequate control of the air pollution problem, carefully trained supervisors who live close to the refinery notify management of any condition that appears serious. In addition, a daily inspection is made each morning of atmospheric conditions around the refinery. The conservation inspectors mentioned above also check for possible air contaminants and odors throughout the refinery during the day.

Laboratory analysis of atmosphere. The refinery has retained an independent laboratory to make air analyses twice each month in and around the refinery. On one day near the first of the month, the analyses are made in the refinery at six points. Near the middle of the month, samples are taken at locations around the plant but several blocks from the refinery. All samples are taken in a well equipped mobile laboratory and analyzed for contaminants that might be expected from a refinery. In addition, these consultants will make analyses in case of serious complaints. Their data to date indicate that the refinery is not contributing appreciably to air pollution in the area.

Inspection of vegetation. A plant pathologist at Louisiana State University is retained to make a complete inspection of the many trees and plants throughout the refinery every three months to determine if they indicate any evidence of damage from air pollution.

In addition to the engineering and other similar technical personnel assigned to the problems of air and water pollution control, an industrial hygienist is also available on the refinery staff and assists in problems of air contamination.

A few complaints have been received from time to time. These have been carefully checked, and a report is kept of the complaint and the condition found. In the very few cases where the refinery was at fault, every effort has been made to correct the condition promptly.

Pollution control at Esso's Baton Rouge refinery is recognized by upper management as an integral part of the refinery operation, and through the assignment of necessary personnel and the development of a planned program over the past years has resulted in appreciable reductions in the discharge of potential pollutants as well as economics in operation. * * *

"Polyvis" Comes To Southwest

Cosden Petroleum Corporation, plunging independent refiner-producer of Central West Texas, adds to its ulramodern facilities by building and operating a million-gallon-per-year polybutene unit, the design of which was made in the light of data obtained by operating a pilot plant unit for the same process. Marketing and distributing organization is being worked out with centers in more than a dozen large cities east of the Rockies. Anhydrous aluminum chloride is the catalyst employed, and reaction temperature may go as low as minus 30-40 F, depending on the viscosity of the product desired. Saybolt viscosities may vary from 100 seconds at 100 F to 20,000 seconds at 210 F. It is not subject to air oxidation, is essentially clear, and is used in caulking and sealing compounds, vibration dampeners, pressure-sensitive adhesives, and is believed to have a great future in electrical applications because of its peculiar properties.

EXCLUSIVE

FIG. 1. Smoking flame (right) caused by incomplete combustion fills atmosphere with soot and smog producers. A common sight a few years back, this situation is seldom seen nowadays.

FIG. 2. By sending a series of small steam jets into the combustion mixture clear, smokeless or nearly smokeless flames result, abating the smoke nuisance.

"Smoke and Fumes"

Keeping 'Clouds' from the Horizon

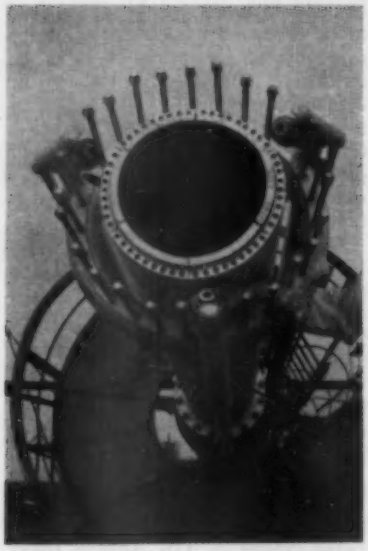
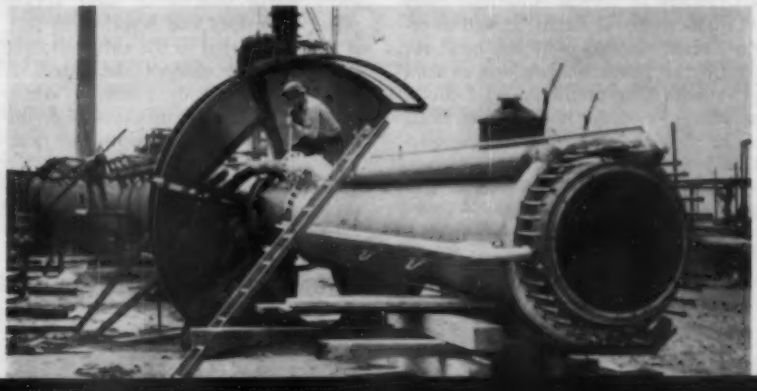


FIG. 3. Details of the stack burner (above). Three equally spaced igniters or "lighters" are placed around the periphery of the stack top; numerous small pipes support steam jets directed radially inward. FIG. 4. The latest design of flare stack head (below) with "lighters," steam jets; note the insulated steam ring into which the jet pipes are let, and the steam feeder line alongside the stack.



IN the accompanying illustration No. 1, is shown one of the commonest causes of atmospheric pollution, smoke from incomplete combustion of burnable materials. In this case are shown the flare stacks of a typical modern refinery (Cities Service Oil Company, East Chicago). No matter how efficient a refinery is operated—and the almost unbroken rule among them is for very high efficiency — at times it is necessary to flare hydrocarbon gases, that is, allow them to pass to the air. This is a highly hazardous procedure, so plants arrange stacks with igniter mechanisms to burn these gases and vapors. Result: incomplete combustion, if burned without adequate preparation, forming large amounts of carbonaceous matter, oxidized hydrocarbons, as aldehydes, oxides, acids, etc. These latter materials more often than not irritate human body membranes, eyes, skin, nostrils, and cause trouble and suffering among people.

Illustration No. 2 shows what happens to these same smoky installations, when arranged properly to give complete combustion. Steam is admitted through the several small tubes extending upward from the outside rim of the stack, shooting into the mixture of hydrocarbons and air to give strong turbulence and thus bring all combustibles into intimate contact with oxygen of the air to be burned without soot formation.

The result here is a clear brilliant flame that consumes all of the hydrocarbons and discharging only carbon dioxide and water vapor into the atmosphere. This eliminates the smog producing waste products and prevents the condition known by that name. Also, smoke clouds and soot deposition are eliminated from this area. No. 3 shows a close-up of the flare stack, with its three igniters equally spaced around the top, the "stockade" of steam jets all around, and C. S. Plant Man Ray Pierce standing by, showing relative size of the stack burner. No. 4 shows a similar burner being assembled en site for Tidewater's 130,000 B/D Flying A refinery near Wilmington, Delaware. This unit will be 225 ft high when in position. ★ ★ ★

Air Pollution

Great Strides Made In Smoke & Fumes Research

Presence of nitrogen dioxide, ozone, etc., found to promote smog formation; new methods showing way to problem solution

L. C. Kemp, Jr.
The Texas Company

THE research program in effect at the time of the last midyear meeting was described in a handout entitled "The Smoke and Fumes Committee and Its Research Program." It may be recalled that 10 projects were described in this paper; two of them had been completed, and eight were active. Soon after the May, 1955 meeting, the three projects located at The Franklin Institute in Philadelphia were combined into one project. Now, a year later, four more of the original research projects are terminating at the close of the current contract year, and negotiations are under way to activate four new projects.

The direction of the program is being changed as the results from research become available to clarify the technical aspects of air pollution. The executive secretary maintains close liaison with other agencies active in this field; e.g., the Air Pollution Foundation, by membership on its Technical Advisory Committee; the American Society of Mechanical Engineers, by membership on its Committee on Air Pollution Controls; the Group on Composition of Exhaust Gases of the Coordinating Fuel and Equipment Research Committee (CFR), through active participation in its group and panel meetings; and the Western Oil and Gas Association.

Completed Research

The first research project to be completed under the Smoke and Fumes Committee's research program related to the determination of the amount of hydrocarbons and partially burned hydrocarbons present in the flue gases from several types of domestic and industrial burners and furnaces using petroleum products. This project, at the Armour Research Foundation in Chicago, comprised a field survey of 74 installations. These installations varied from domestic hot-water heaters to industrial furnaces with fuels ranging from natural gas to No. 6 fuel oil. In some instances there was considerable maladjustment of the burner involved. In all cases, less than 100 ppm of hydrocarbon or derivatives was present in the flue gas. In almost all cases there was less than 50 ppm, and in most of the cases there was no detectable amount of hydrocarbon. One must conclude that the contribution of stationary combustion processes using petroleum products to the organic material emitted to the atmosphere is not serious. These data indicate that this source of pollution is far less than one per cent of the total organic material put into the atmosphere in a modern American city.

In another project now completed, and carried out at the Kettering Laboratory at the University of Cincinnati, a survey of the so-called oxidant (expressed as ozone) and oxidant-precursor content in several American cities was conducted. It might be well to review briefly at this point the basis for the interest in the oxidant and oxidant precursors. One of the unusual effects associated with the Los Angeles smog is the presence in the air during daylight hours of unusually high concentrations of an oxidizing material that behaves chemically like ozone.

From the evidence available to date it seems probably that a good share of this oxidant is actually ozone, although it is fairly certain that other more complicated oxidants are also present. The oxidants including ozone are believed to be produced by the action of the sun's rays on certain pollutants in the air. These substances from which the oxidant is produced by the action of the sun are grouped under the broad term of "oxidant precursors." Their presence is measured by subjecting a sample of night air to artificial radiation.

Oxidant was recorded in cities that fall into four classifications: Those with heavy automobile traffic and minimum industry, like Washington, D. C.; those with oil refining plus general heavy industry, like Philadelphia, Pennsylvania; those with general heavy industry but with a minimum of oil refining, like Akron, Ohio, and those having a heavy concentration of chemical industry, like Charleston, West Virginia. In all of the cities surveyed, the oxidant recorded was in the low range typical of Los Angeles under non-smog conditions.

Measurements of the SO_2 concentration, made at the same time, brought out the interesting fact that all of the cities investigated usually had much more sulfur dioxide in their atmosphere than does Los Angeles. In fact, it was found that as the sulfur dioxide increased, the oxidant decreased. A more detailed study made at Washington, D. C., and in Cincinnati, under conditions when little sulfur dioxide was found, showed higher oxidant values than when the SO_2 concentration was higher. This relation held for oxidant precursors as well. In Wash-

Presented to a session on smoke and fumes during the 21st Midyear Meeting of the American Petroleum Institute's Division of Refining, May 16, 1956.

ington, D. C., when SO_2 concentration was of the same order as it is in Los Angeles, the ozone and oxidant-precursor values were approximately one tenth of those observed in Los Angeles on mildly smoggy days.

The full significance of this relationship between oxidant and sulfur dioxide is far from clear. It is certainly indicated, however, that elimination of SO_2 emissions to the air does not result in lower oxidant formation, and may actually permit the oxidant concentration to reach higher levels than would be the case if sulfur dioxide were present in larger amounts. Some further observations in this connection are presented later in this paper in relation to another project.

Projects Now Being Terminated

For three years the largest project in the Smoke and Fumes Committee's program was carried out at Stanford Research Institute's laboratories in Pasadena, California. In this work studies have been made on the mechanism by which ozone and other oxidants are formed in the atmosphere and on the development of methods for determining the oxidant-forming potential of polluted atmospheres. The work at Stanford Research Institute, supported by the American Petroleum Institute and others, has contributed a large amount of significant knowledge in the field of air-pollution chemistry. For example, the method of measuring oxidant with potassium-iodide recorders was developed at Stanford Research Institute, as was the method of determining oxidant-precursor values. The latter development resulted from the observation made at Stanford that if night air, collected when the atmospheric conditions were such that smog was likely to be produced the next day, was irradiated by ultra-violet light just below the visible range of wave length, high concentrations of oxidant would form. In other words, there were materials in the atmosphere that, although they did not possess oxidant properties, would form oxidant upon irradiation with natural or artificial light.

Work carried out later indicated that the presence of nitrogen dioxide in the atmosphere was a key to this photochemical reaction. The available information gives strong support to the following postulation of the course of the reaction. The nitrogen dioxide absorbs light to form nitric oxide (NO) and an atom of oxygen. The latter combines with molecular oxygen to form ozone. Because it is known that nitric oxide is oxidized rapidly to nitrogen dioxide by ozone, the mechanism of oxidant formation must involve the removal of nitric oxide by some other means. The oxidant-forming tendencies of many organic materials have been investigated by Stanford and other laboratories, and great differences have been found to exist. The mechanism of the reaction which occurs after the primary photochemical process involving the nitrogen dioxide is very complicated and has not yet been unraveled. Some reaction products have been identified by others, and it is believed that the mechanism will soon be clarified.

The Stanford project has just been completed, and our thanks to them, for contributing so much knowledge of the chemistry of the air, are in order.

A project at the Industrial Hygiene Foundation of America is just being terminated. In this case a method was developed for tracing the path of gases after emission from a stack to any point downwind. After a laboratory investigation of several methods found suitable, a full-scale test on the most promising method was carried out. This method involves the suspension of finely divided antimony oxide in the stack gases and the collection of samples at various downwind locations on a sampler developed at the Industrial Hygiene Foundation. These samples are analyzed for antimony by irradiating them in the Oak Ridge reactor and determining the antimony content by a counting technique. These results have been assembled, and a final report is in preparation. The Project Advisory Committee is contemplating the preparation of a method for use by industry for tracing gas streams. This should provide a useful tool for the petroleum industry and others active in air-pollution control.

Another project at the Armour Foundation is just being concluded. This one is on the development of a quantitative method for analyzing ozone in the atmosphere, which is specific to ozone as distinguished from other oxidants, and which can be made relatively portable.

The method involves, in substance, a measurement of the heat released when the ozone is catalytically decomposed to molecular oxygen. The catalyst employed is highly selective to ozone decomposition under the conditions used, and the heat released is measured by determining the temperature rise in the sample resulting from the decomposition. Highly sensitive elements called thermistors are used for this purpose. It is planned to field-test the instrument in the Los Angeles area at a time when the ozone concentrations are in the higher regions typical of smog conditions. This will permit comparison with other methods of ozone analysis now being used. If these tests indicate that the instrument has been satisfactorily developed, it will be made available to anyone interested in its use in other studies and operations in which accurate ozone determinations are important.

Another research project that will close at the end of June this year is one being carried out at the University of Illinois under the direction of Professor H. F. Johnstone. Professor Johnstone and his co-workers have studied the oxidation of sulfur dioxide to sulfur trioxide under conditions which may exist in the atmosphere. They have found that the oxidation is very slow and that formation of sulfur trioxide from gaseous sulfur dioxide cannot account for the reduction of visibility observed in atmospheres during a few hours of daylight, nor can it account for the high sulfate content of particulate matter found in some cities.

The atmospheres of many American cities contain much sulfur dioxide. This sulfur dioxide at high concentrations over about 1 ppm can cause damage to sensitive plants. Below this threshold value, sulfur dioxide in the atmosphere is innocuous. Here again is evidence which seems to indicate clearly that elimination of SO_2 emissions beyond that required to get below the threshold value will have little, if any, effect in reducing the undesirable results of atmospheric pollution. In fact, such elimination may result in an increase in the undesirable manifestations.

Projects Being Continued

Another project at the University of Illinois is being continued. The primary objective is to study the rate at which visibility may be reduced or other manifestations of polluted atmospheres may appear as a result of the reaction of hydrocarbon and ozone in the presence or absence of other

The Author

L. C. Kemp is "bossman" of The Texas Company's petrochemical department, in the New York office of the parent company. Graduated from Rice Institute, Houston, BS in chemical engineering a quarter century back. Climbed the 'stairs' in his company from researcher in Port Arthur, Texas, to senior vice presidential assistant via the research directorship; is chairman of the Technical Advisory Committee to the API Smoke and Fumes Committee, and so made the following report of its activities, last spring (1956).

materials. This project has been activated within the past several months. No results are yet available to report, but the vigor with which Professor Johnstone is approaching the problem portends that interesting information will soon become available.

The last of the older projects which will be continued, and with increased emphasis, is the project at The Franklin Institute. This project, under the technical direction of William E. Scott, has made many significant contributions. The development at Franklin of the long-path infrared cell for studying atmospheric reactions has led to a great deal of new knowledge about these reactions. This work has been recognized throughout the country as an outstanding piece of research. The United States Public Health Service is giving consideration to having one of these instruments made for research on atmospheric pollution. The first results of Franklin work with the long-path cell were presented at Minneapolis last September at a symposium of the American Chemical Society. The paper was extremely well received, and the Institute has been invited many times to give the paper to other groups. The latest findings by this group are reported by Scott.*

New Research Program

The new research program of the Smoke and Fumes Committee, which began officially on July 1, 1956, includes four new projects. The largest of these involves the construction of another long-path infrared cell by The Franklin Institute for studies of the concentrations of materials in the atmosphere, and for extending the mechanism studies being carried out in the Franklin laboratory in connection with the institute's current project. This new cell will be semiportable, and will be located first in Pasadena where studies with it can be integrated with those of the Air Pollution Foundation. Measurements on the atmosphere are also being made by the Los Angeles County Air Pollution Control District and Professor Haagen-Smit at that location.

It is believed that the simultaneous determination of materials by the highly sensitive infrared techniques developed by Franklin will be extremely valuable in determining what is going on in the air. The cell will, of course, be capable of studying reaction mechanisms with purified air as well as air taken from the polluted atmosphere that may exist during a smoggy season. Making the cell portable will allow these measurements to be made at other locations. Because the method gives unequivocal determination of ozone and some other materials, it is possible that this instrument or some suitable modification will be of interest for atmospheric monitoring purposes. The American Petroleum Institute instrument will be operated by personnel of The Franklin Institute. Construction of the instrument has already been started, and it will be put into operation as soon as possible.

Although much additional information on the matter must be obtained, it is already known that a substantial amount of the hydrocarbons in the air come from internal-combustion-engine exhausts. The automotive industry is working diligently on methods of eliminating, or at least drastically reducing, this source of hydrocarbon emissions.

As part of this general activity the CFR Group on Composition of Exhaust Gases, which is currently carrying out a survey of the amount of organic material, nitrogen dioxide, nitric oxide, and carbon monoxide emitted by automobiles under actual city-driving conditions, is sponsoring a research project at the Bureau of Mines in Bartlesville, Oklahoma. An analytical technique, which employs the principles of gas chromatography is being applied for detailed analyses of exhaust gases. This CFR project derives half its support from the API through the Smoke and Fumes Committee. The other half of the support comes from the Automobile Manufacturers Association. Development of this method of analysis will allow much more detailed studies of exhaust-gas composition than have been possible to date.

As has been brought out, the Smoke and Fumes Committee research carried out at The Franklin Institute and Stanford Research Institute, and the research by other sponsors, has led to the identification of reaction products which may be responsible for some of the manifestations of polluted atmospheres. It is known that the typical damage to plants which occurs in industrial areas is not caused by sulfur dioxide, ozone, hydrocarbons, formaldehyde, or oxides of nitrogen. The effects of the new reaction products recently identified have not been determined, and a new project at the University of California, at Riverside — where John Middleton, an outstanding plant pathologist in the field of air pollution, will test these materials —is therefore being activated. This project, integrated with the one at the University of Illinois and some Air Pollution Foundation projects relating to eye irritation, should provide valuable information concerning the reaction products which are the real culprits in the atmosphere.

Finally, a project is being started on a study of all the possible methods which might be used to isolate and identify all the constituents present in a polluted atmosphere. Although the usual analyses for ozone, oxidant, sulfur dioxide, particulate matter, and nitrogen oxides have been made many times, a complete analysis for the organic constituents has not yet been made. Indications have been obtained from analyses of condensed samples, but the analyses have been incomplete or made by methods open to question.

Two outstanding men in the country, capable of evaluating methods of analyses, are studying the possible techniques. These techniques range from gas chromatography to wet-chemical analysis; use of infrared or ultraviolet procedures; and methods such as condensation of samples from gigantic masses of air, followed by fractional distillation, mass spectrometry, and infrared analyses. Work of all the other investigators is to be reviewed as part of the study. It is believed that the availability of complete and reliable methods of analysis of the atmosphere for other than the usual constituents is necessary to determine causes and cures of air pollution.

Every effort is being made to integrate the Smoke and Fumes Committee's research program with all the other work going on in this country. This in itself is no small task. The Air Pollution Foundation has an annual research budget of from $500,000 to $1,000,000. The United States Public Health Service can spend up to $5,000,000 yearly on research. Many states, counties, and cities are carrying out work which totals a large sum. Much of this work is of the monitoring type and is not true research on the fundamentals, but the results of this monitoring are of great value in determining causes and cures.

As stated, the petroleum industry is aware of its responsibility as a member of the many communities of this country. It is supporting the Smoke and Fumes Committee program which costs approximately $250,000 yearly. The Smoke and Fumes Committee and its Technical Advisory Committee feel strongly the responsibility of seeing that these funds are spent wisely. It is believed that the program to date has produced substantial results. It is to be expected that, with the very fine cooperation and active interest in the projects shown by the project workers and by the many able representatives from industry on the various committees, even greater progress will be noted in the future. ★ ★ ★

*In "Recent Developments in the Study of the Organic Chemistry of the Atmosphere," also presented to this session.

EXCLUSIVE

World's First Hydrodesulfurizer

Highly Efficient Trickle Technique Produces Low-Sulfur Middle Distillates at Low Cost

Walter Sekules
European Correspondent

THE first commercial hydrodesulfurization unit applying the Shell Company's trickle-phase technique has been operating since April, 1955, at Stanlow, England, refinery of Shell Refining and Marketing Company. It has been processing light, catalytically cracked cycle oil to the full satisfaction of Shell engineers, who state that no major complications have arisen in early months of operations. Meanwhile, it has been announced that license arrangements have been settled for the erection of trickle-phase desulfurizers in Canada and Italy.

This desulfurization process is designed for the production of low-sulfur middle distillates from high-sulfur stocks. Its three main economy features are:

(1) In application of the trickle technique, the feed stock is trickled in liquid form over a fixed bed of catalyst, and a low hydrogen recycle rate is employed. This results in a 15 to 20 per cent saving in capital investments and operating costs as compared with gas-phase hydrogenation.

(2) Sulfur removal of 85 to 90 per cent is easily obtainable with catalytically cracked and straight-run cycle oils. Runs carried out at different throughputs at the Stanlow unit showed that 90 per cent and more desulfurization was obtained for feed rates of 5500 B/D and 7000 B/D.

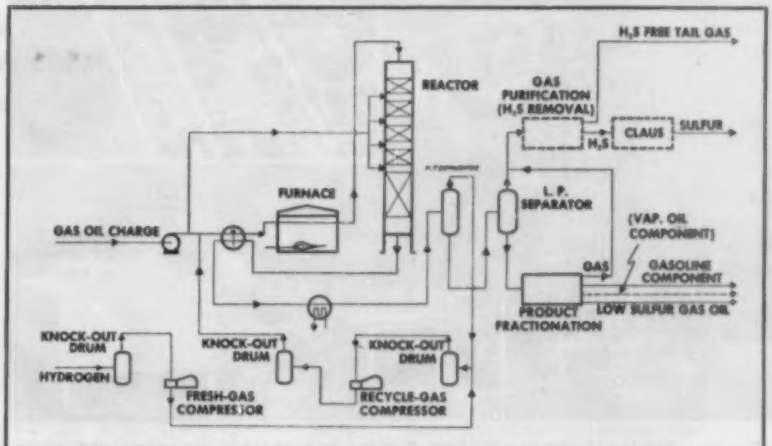
(3) High octane gasoline, obtained as a by-product from catalytically cracked cycle oil, and hydrogen sulfide contribute materially to the economy of the process. The gasoline obtained at Stanlow had a clear Research octane number of over 100 and amounted to 5 per cent on feed.

The development of the trickle-phase desulfurization process has taken place at the Royal Dutch Shell Laboratory at Amsterdam, where extensive laboratory and pilot-plant investigations were carried out over a number of years. It was found that the cost of hydrodesulfurization could be reduced considerably by decreasing the amount of recycled hydrogen. Reduction of the amount of cycle gas considerably below the conventional level would have resulted, however, in operating conditions under which most of the feed would no longer be vaporized but remain in the liquid state. Extensive research showed that a high degree of desulfurization with a relatively small amount of hydrogen gas could be obtained by the use of a process in which the oil was allowed to trickle over a solid catalyst in a hydrogen atmosphere. It was found that under these low hydrogen recycle conditions the catalyst activity was not impaired at all. Moreover, it could be shown that this technique could be applied to a variety of base materials and with catalysts of different nature. Factors contributing to the economy of the trickle-phase process include the reduced capacity and power consumption of the hydrogen recycle compressors and a reduction in the heat-transfer surface area required since a considerably smaller amount of heat has to be transferred through feed/products heat exchange, while the fired pre-heater can also be relatively small.

In developing the catalyst, it was found necessary to insure that it should be selective under the operating conditions, applied-hydrogen consumption should be limited essentially to that required for the desulfurization reaction, while side reactions such as hydrogeneration of aromatics should be avoided or suppressed. A cobalt-molybdenum-alumina catalyst was specially developed to give optimum hydrodesulfurization performance with very little hydrogenation of aromatics even at a high degree of sulfur removal.

Following are design features of the Stanlow unit, applying the above principles:

The hydrogen to be consumed during the hydrodesulfurization reactions and the hydrogen-rich recycle gas used for catalyst protection are compressed to the operating pressure with separate compressors. The compressed hydrogen-rich gases are combined with the major part of the charge-oil and introduced into feed-product heat exchangers and reactor charge heater, and heated to reactor inlet temperature. The remaining part of the charge oil is fed cold to the reactor to dissipate the heat of the reaction. The reactor products — consisting of hydrogen, light hydrocarbons, partly vaporized, desulfurized cycle oil, and hydrogen sulfide-exchange heat with the reactor feed, are cooled down further, and are finally introduced into the high-pressure separator, where a hydrogen-rich gas is separated. The gas is recycled and, if necessary, partly bled into the refinery fuel gas system after being scrubbed with diethanolamine to remove the hy-



Simplified flow chart of hydrodesulfurizer unit at Shell's Stanlow, England, refinery.

An "oxbow" of the River Gowy at Stanlow in the Shell refinery plot; the river has been straightened by cutting across the "oxbow" to increase available ground space.

drogen sulfide. The HP separator liquid is flashed in the LP separator and introduced into the fractionating section.

In this section, consisting of a main fractionator and two side strippers, the desulfurization product is split into three fractions while the dissolved light hydrocarbons and hydrogen sulfide are removed overhead. The overhead gases are combined with the gases flashed off in the low-pressure separator. When processing light cat-cracked oil, the reactor products are split into a highly aromatic, heavy gasoline fraction, a 428 to 439 F fraction and as a main product a bottom fraction boiling at above 500 F. Reboiler heat for the strippers is supplied by a slipstream taken from the fractionator bottom stream. A reboiler furnace supplies heat to the main column.

When the Stanlow hydrodesulfurizer came into operation, it was found that the reactor, designed for an expected throughput of 5500 B/D, had in fact a much greater capacity. Resulting bottlenecks are now to be removed to conform with the greater reactor capacity. Though the basic principle of the reactor will remain, it will be possible to design it more closely for future units. Space velocity at the originally planned throughput of 5500 B/D amounted to 1.27 vol/vol/hr, but the unit has in fact been operating at 7000 B/D and a space velocity of 1.59 vol/vol/hr. The reactor was designed for an operating pressure of 800 psi at 1000 F in a hydrogen-sulfur atmosphere. It contains a total of nearly 25 metric tons of the cobalt-molybdenum-alumina catalyst divided over six beds. Even distribution over the catalyst is ensured by special devices. A two-foot layer of ceramic balls is added on top of the upper catalyst bed as a scale catcher. After three months operation, there was no sign yet of any deterioration of the catalyst. Designed to last six months, the catalyst is now expected to last for a total of ten months or more before it will be regenerated *in situ*. About 20 per cent of the charge oil is used as cooling oil to limit the reactor outlet temperature to the desired level.

Results obtained with the first trickle-phase desulfurizer compare favorably with design values, according to Shell engineers. The 500 + F fraction contained only 0.3 wt per cent sulfur. The sulfur contents of the other fractions were lower than anticipated.

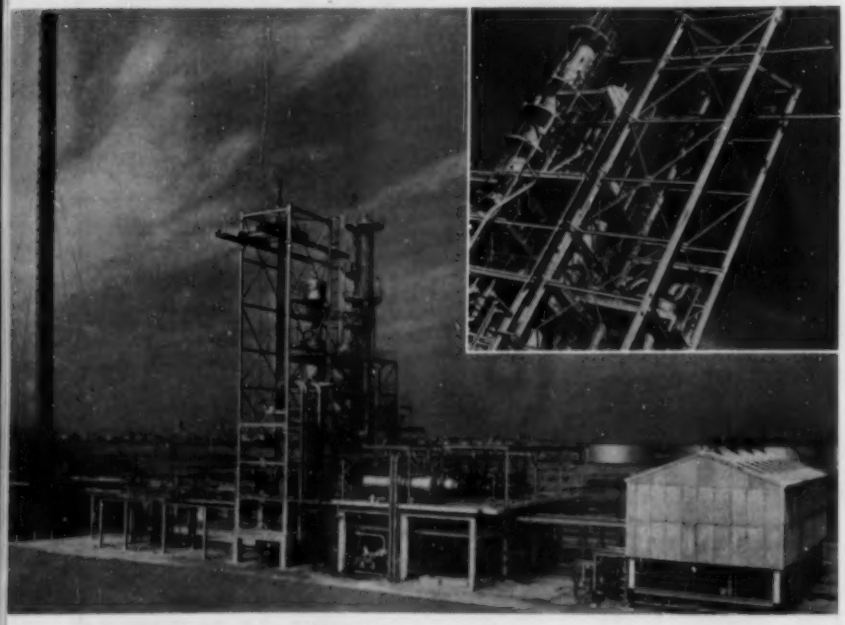
Product distribution was, as expected, nearly 70 per cent on feed boiling above 500 F. The gasoline had a clear Research octane number of over 100 and amounted to 5 wt per cent on feed. All products met the specifications required of the various streams by the product department.

Temperature control of reactor beds by means of cold oil injected into the various mixing-distributing trays proved to be excellent. No temperature runaways were observed. The effect of injection of cooling oil could easily be traced by the temperature readings.

After several months operation of the world's first commercial trickle-phase hydrodesulfurizer, the Shell company points to the simplicity of operating this process. Experiments made with the first unit will enable Shell engineers to design more exactly for intended throughput. They believe that trickle-phase hydrodesulfurization will have a very big future.

The Stanlow hydrodesulfurizer has been built at a cost of some $2,800,000. Construction began in the middle of 1953, and the unit is almost entirely of British manufacture and materials. Stanlow is now claimed to be one of the most completely integrated oil refineries outside the USA. Included in the facilities on the 2000-acre refinery site are the first Platformer in Europe, a catalytic cracker, a modern chemical plant, a synthetic detergent plant, and an iso-pentane unit. Apart from Stanlow, which is the largest, Shell operates three other major oil refineries in the United Kingdom: Shell Haven, Essex; Heysham, Lancashire, and Ardrossan, Ayrshire. Total annual capacity of the four installations amounts to some 10,000,000 tons (about 70,000,000 bbl).

★ ★ ★



The new Stanlow hydrodesulfurizer, first for its process in the world and costing £1,000,000 ($2,800,000), will refine largely diesel and tractor fuels. Towers, heat exchangers, at upper left, of the hydrodesulfurizer.

EXCLUSIVE

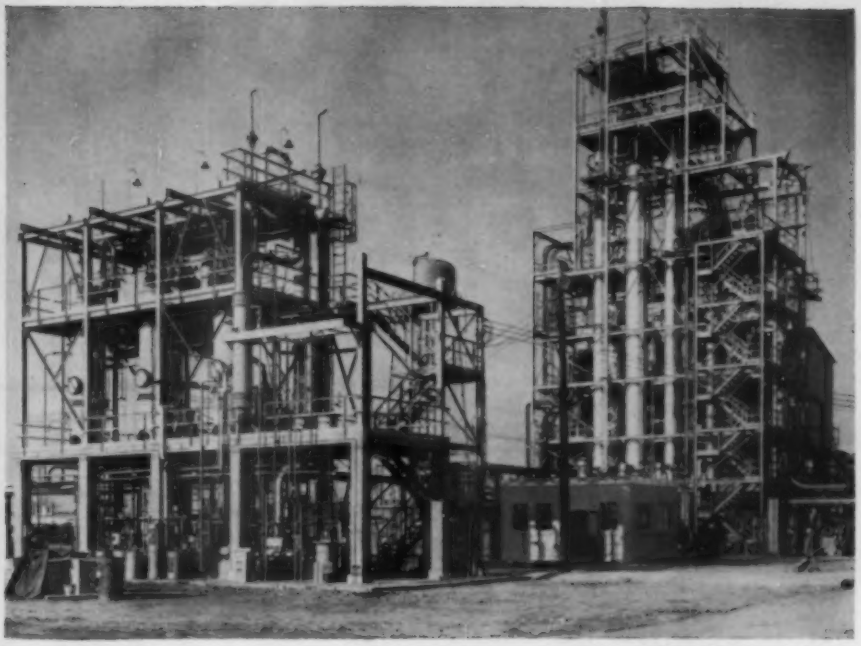


FIG. 1. View of a part of a vinyl acetate plant at Calvert City, Kentucky. *Courtesy: Air Reduction Chemical Co.*

Petrochemicals Unlimited

PART VI: Miscellaneous Major Chemicals

Peter W. Sherwood
Chemical Engineer

Ethanolamines, substituted aromatics, nitriles and nitroparaffins make up another great division of petrochemical production

Acrylonitrile

SPURRED by its consumption in the manufacture of such synthetic fibers as orlon, acrilan, dynel, and X-51, acrylonitrile has become one of the important growth chemicals of the 1950's.

As recently as 1953, acrylonitrile production was only 57,000,000 lb, of which 50 per cent entered the production of nitrile rubbers (Buna-N, GR-A). Forecast for 1956 indicates an acrylonitrile output of 160,000,000 lb, and a complete shift in sales pattern:

Estimated 1956 End Distribution of Acrylonitrile

	(millions of lb)
Nitrile rubber	25
Synthetic fibers	100
Plastics	25
Miscellaneous	10
	160

Two routes are employed for the commercial synthesis of this chemical. Most, if not all, of the large new plants that have been erected since 1952 employ the direct synthesis from acetylene and hydrogen cyanide. However, there continues to be acrylonitrile production by the classical two-step process, starting with ethylene oxide and hydrogen cyanide. It is this route that is of interest within the scope of the present article series.

$$(CH_2)_2O + HCN \rightarrow CH_2OH \cdot CH_2 \cdot CN - H_2O \rightarrow CH_2 CH - CN \quad (1)$$

Reaction between ethylene oxide and hydrocyanic acid is carried out in the presence of water and an alkaline catalyst. In one commercial operation, the preferred composition of the reaction medium is 200 vol. parts water, 8 parts diethylamine and 5 parts 50 per cent aqueous NaOH.

The reactor is a vertical cylindrical cast-iron vessel, provided with agitator and cooling coil for the removal of the exothermic reaction heat. Ethylene oxide is introduced at a point near the bottom of the kettle, while liquid hydrocyanic acid is fed to the system at a point above the liquid surface. Vent gases are cooled to —10 C in an overhead heat exchanger in order to minimize raw materials losses.

The reaction is started at 5° C. The raw materials are introduced in equimolar quantities at a rate compatible with the cooling facilities. Addition of raw materials is stopped when about 6 to 7 volumes of ethylene oxide have been introduced per volume of water initially present (this may take up to 10 hr).

At this point, the system temperature is raised to 60 C, where it is held for several more hours to permit more complete utilization of the raw materials. The alkaline mixture is finally neutralized and purified by distillation at 100-150 mm Hg abs and 100-110 C still temperature. The overhead consists in the main of unconverted HCN, ethylene oxide, and water. Ethylene cyanhydrin is withdrawn as bottoms at 88-90 per cent purity. Contaminants are residual water, polymerized hydrogen cyanide, and salts that were formed during the neutralization step. This crude product may serve as feed to the dehydration step without further purification. Overall yield is 88-89 per cent of theory.

In a modification of this process, a portion of the crude ethylene cyanhydrin is used to absorb ethylene oxide and hydrogen cyanide as they are evolved during the topping operation. This stream of cyanhydrin, together with absorbed raw materials, is recycled to the reactor. This version has certain operating advantages and reduces refrigeration requirements. It does not, however, appear to have a favorable effect on overall yield.

The dehydration of ethylene cyanhydrin is carried out commercially in the *liquid phase*. The patent literature

contains several references to *vapor-phase* dehydration in the presence of catalysts (activated charcoal, alumina, etc.). This method appears to offer unsatisfactory yields, however, and obstructions form readily to destroy catalyst activity.

Numerous catalysts can promote the dehydration reaction effectively, among them: Tin, sodium bisulfate, ammonium phosphate, magnesium oxide, magnesium carbonate, etc. It is the last named that has found commercial application in German technology. According to the trend of the patent literature, American practice has been developed along the same general lines.

Liquid-phase dehydration lends itself to semi-continuous operation. Crude ethylene cyanhydrin is charged to an agitated cast-iron kettle together with magnesium carbonate (in the approximate ratio 12:1).

The charge is heated to 200 C, the dehydration temperature. Acrylonitrile and water are taken overhead, and an equivalent amount of make-up ethylene cyanhydrin is continuously charged to the reaction vessel until the consistency of the bottoms impedes further operability.

In addition to the two reaction products, the overhead vapors contain some unconverted ethylene cyanhydrin. This is condensed in a dephlegmator and refluxed to the reactor. Acrylonitrile and water are then recovered in a final condenser.

Two phases are formed, and the organic layer, after separation, is distilled for the recovery of polymerization-grade acrylonitrile. To inhibit yield-wasting polymerization, a stabilizer (p-phenylene amine and methylene blue) is added to the still charge.

The lightest boiler is the acrylonitrile-water azeotrope, which is, of course, recycled to the original still charge. Commercial acrylonitrile passes overhead as intermediate boiler.

The heavy components are subjected to a final heating for the complete removal and recovery of residual acrylonitrile, and are finally discarded.

Ethanolamines

Production of ethanolamines has, during the past three years, taken an impressive and continuing upward spurt. Combined 1955 output (by four manufacturers*) is estimated at 80,000,000 lb. This compares with 44,000,000 lb in 1952, 53,000,000 lb in 1953.

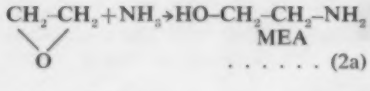
The development is paced by the expansion of Ninol-type detergents, which are derived from diethanolamine. Other growing uses for DEA include production of petroleum demulsifiers, rubber accelerators, corrosion inhibitors.

As a result, diethanolamine has now taken the lead among ethanolamines, the position held by monoethanolamine until 1953. A recent study[1] estimates the 1955 line-up as follows: Monoethanolamine — 28,000,000 lb; diethanolamine — 32,000,000 lb; triethanolamine — 200,000,000 lb.

Scrubbing of sour gases continues to be the main use for monoethanolamine, accounting for 45-50 per cent of the market. With increasing natural gas use and more extensive sulfur recovery from refinery gases, applications for MEA as acid gas scrubbing medium face a bright future. In the second place among MEA outlets (accounting for 25-30 per cent of total consumption) is the production of coconut fatty acid amides, used as builders in synthetic detergents. Miscellaneous MEA outlets include plasticizers (for cellophane), household polishes, etc.

Triethanolamine has, at present, the least active market. Fifty to 55 per cent of its output enters the manufacture of toilet goods. Production of textile specialties, waxes, rubber chemicals, etc. accounts for the remainder.

Production methods for ethanolamines involve reaction between ethylene oxide and ammonia:



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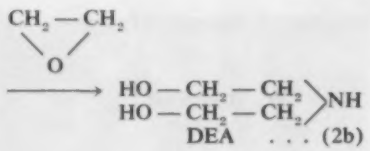

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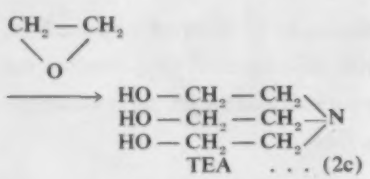

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These are equilibrium reactions. It is furthermore found that ethylene oxide reacts more rapidly with alkanolamines than with ammonia. It is, therefore, necessary to employ a very substantial excess of ammonia above the stoichiometric ratio. This is true even when triethanolamine is the chief desired product since it will react with ethylene oxide to yield tetraethanol ammonium hydroxide, a strong base that promotes further side reactions to yield oxyalkyl ether of triethanolamine. (This may be suppressed by addition of CO_2.)

Operating in a 25 per cent aqueous ammonia system at 25-30 C, the following equilibrium compositions are obtained:

Mole ratio $C_2H_4O:NH_3$	Mono-	Wt. % Di-	Tri-ethanolamine
0.25	39	39	22
0.50	25	37	38
1.00	11	25	65

Reaction equipment is a cast-iron tower, provided with internal cooling coils. In one commercial installation, the process is carried out on a batch basis. A batch of 30 per cent aqueous ammonia is circulated through the tower and is joined by a stream of ethylene oxide, fed to the base. Temperature is held at 35-40 C. After all ethylene oxide has been added, a 1 to 1½-hr hold-up period is provided.

For monoethanolamine production, ammonia : ethylene oxide weight ratio is 3.6:1 to yield 50 per cent MEA, 30 per cent DEA, 15 per cent TEA, and 5 per cent residue. For triethanolamine production, the ammonia : ethylene weight ratio is 0.20-0.24.

The reactor make is freed of excess ammonia and water by vacuum distillation. This is followed by vacuum fractionation for isolation of the different amines.

The process is also suitable for continuous operation.

As stated above, the addition of CO_2 to the reaction system inhibits the formation of oxy ethers of triethanolamine. This is of particular importance if the tri-substituted amine is the desired product since such operation calls for relatively high ethylene oxide: ammonia ratio. The effect of CO_2 addition on the reaction of 1 mole ammonia with 1.8 moles ethylene oxide has been illustrated by Groggins.[2]

Product composition	With CO_2, per cent	Without CO_2, per cent
Monoethanolamine	0	0
Diethanolamine	5.5	5.1
Triethanolamine	92.5	73.5
Triethanolamine ether	0.3	19.6
Residue	1.7	1.8

Dodecyl Benzene Sulfonate

Wide public acceptance of synthetic detergents has caused a major boom in the production of alkyl and sulfonates. This group of compounds is today mainly derived from petroleum sources. Fully 64 per cent of the 1953 production of surface-active agents was based on petroleum-derived raw materials. This ratio has been increased rapidly in recent years. As recently as 1948, other raw materials exceeded petroleum in importance as raw material for synthetic detergents.

A few figures will illustrate the rapid growth of alkyl aryl sulfonate production in the United States. In

*Olin-Mathieson Corporation will soon enter the field as fifth manufacturer of ethanolamines.

One of the 8-cylinder GMXA's compressing low pressure gas for the production of propane, butane and gasoline in the Little Beaver "dry" gasoline plant.

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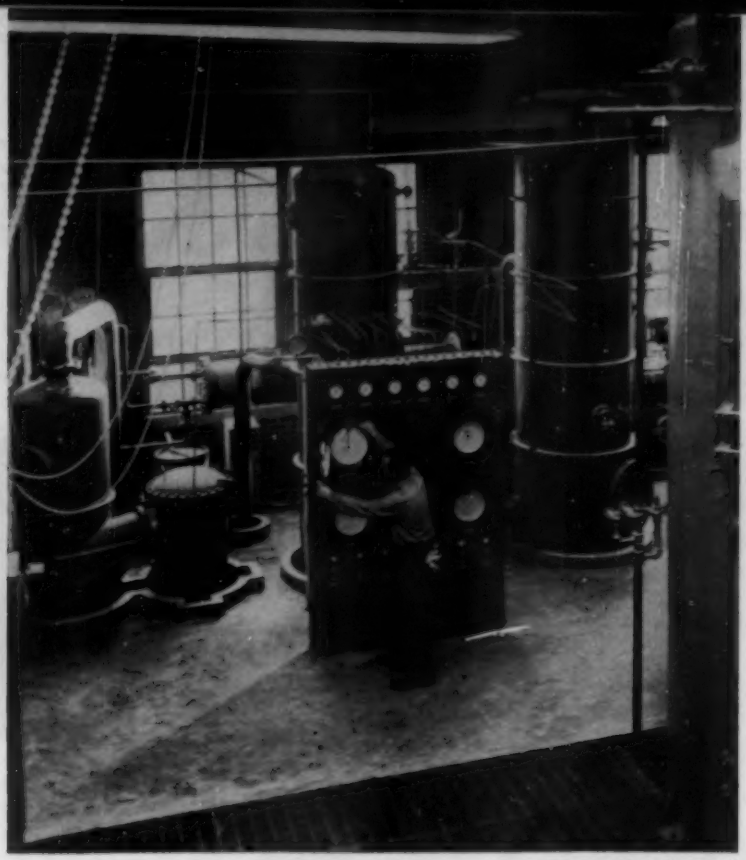

Courtesy: Heyden Chemical Co.

FIG. 2. Evaporators for concentration of aqueous pentaerythritol liquors.

1950, production of these compounds was 277,000,000 lb. By 1953, output had jumped to 370,000,000 lb.

Dodecyl and Keryl benzene are by far the most important alkylates serving as intermediate in the manufacture of these surface-active agents. Of course, other aromatic raw materials have been and are being employed in this application. However, in 1953, benzene and toluene-based detergents were produced at the rate of 364,000,000 lb, while all other types of alkyl aromatic sulfonates accounted for an output of only 6,000,000 lb. Toluene-based detergents made certain inroads into the market during 1950, when the benzene crisis was at its peak. The physical characteristics of these products have, however, proved inferior to the dodecyl benzene derivatives for most applications.

Snell lists advantages that make alkyl aryl sulfonates the most popular synthetic detergents. Those include:

1. The ready availability and low cost of the primary raw material (paraffinic petroleum fraction or propylene, benzene, sulfuric acid, and caustic soda).
2. Simplicity of process and chemical stability of the product.
3. A certain versatility in detergent properties, made possible by variation of the alkyl group employed.
4. Good physical properties and chemical stability of the product.
5. Low production cost.

Production of these materials consists of two distinct phases often carried out at different plants.

1. Preparation of the alkylating aliphatic and alkylation of benzene. This subject has been discussed in Part I of the present series.
2. Conversion of the alkylate to the sulfonate. It is with this operation that the following discussion will be concerned.

Sulfonation of Dodecyl Benzene

Alkyl aromatic sulfonates are produced from dodecyl benzene by sulfonation with oleum followed by caustic neutralization. The active ingredient of the desired surface-active agent is thus the sodium salt of dodecyl benzene sulfonic acid. It is usually marketed in a concentration ranging from 25 to 85 per cent active ingredient. The remainder is sodium sulfate. The percentage of surface-active agent that is present in the sales product depends on the use for which it is intended.

In the sulfonation process most commonly employed, it is necessary to employ sulfuric acid (in the form of oleum) in excess above stoichiometric requirements. Only in this fashion can sufficient conversion of the hydrocarbon be achieved to assure low free-oil content in the finished product. The required amount of excess acid depends on initial SO_3 concentration and on sulfonation temperature.

Of outstanding importance for an efficient sulfonation process is the degree of mixing provided for the two-phase sulfonation mass. As the concentration of oleum increases, this factor acquires increasing significance. High concentration of free sulfur trioxide may result in localized charring and consequent product discoloration, unless special techniques are employed.

In carrying out the sulfonation, all materials of construction in contact with the reaction phases must be corrosion-resistant to prevent iron contamination and consequent discoloration of the product.

A typical process for the batch production of an alkyl aryl sulfonate has been reported by Sharples Chemicals Corporation. In this method, 20 per cent oleum is used, with 1.66 lb oleum being employed per pound hydrocarbon. The product of this operation may contain either 85 or 40 per cent active ingredient, and may be adjusted by the method of finishing.

Dodecyl benzene is first charged to a glass-lined jacketed agitated sulfonator, where it is cooled to 10 C. Twenty per cent oleum is then carefully pumped into the reactor. External cooling is provided and the temperature maintained at 25 to 35 C by controlling the rate of addition. After the entire batch has been introduced into the sulfonator, it continues to be agitated for 1.75 hr to allow the sulfonation to reach completion.

If the product is desired to contain 80 to 85 per cent active ingredient, crushed ice is added to the sulfonation mass. The mass is then allowed to stratify. The organic layer is charged to an agitated neutralizer which contains a 20 per cent sodium hydroxide solution. The addition rate is controlled so that the batch temperature does not exceed 55 C. The pH is finally adjusted to 8, and the slurry is drum-dried, packaged and is then ready for shipment.

Alternately, it is possible to produce a 40 per cent active sulfonate by charging the unseparated product of sulfonation to a neutralizer containing 20 per cent sodium hydroxide solution, again making sure that the temperature in the system will not exceed 55 C. Toward the end of the neutralization step, the requisite amount of anhydrous sodium sulfate is added to the batch. The

pH is again adjusted to 8 and the slurry is ready for drum-drying to produce a 40 per cent active saleable product.

Since 1952, dodecyl benzene sulfonate has been commercially available as the "unbuilt" compound (i.e., substantially free of sodium sulfate). The key to its manufacture is the use of anhydrous sulfur trioxide in lieu of oleum. This agent sulfonates dodecyl benzene with a higher heat of reaction (794 Btu/lb SO_3) that does 20 per cent oleum (210 Btu/lb SO_3) so that more efficient means of heat removal must be provided.

Gilbert et al,[3] have developed two practicable processes in which sulfur trioxide *vapor* serves as sulfonating agent. Air is used as vapor carrier. The two methods differ in the method of heat removal and agitation but are alike in their process aspects.

A gaseous mixture of SO_3 and air is introduced into liquid-phase dodecyl benzene. To bring the viscosity of the sulfonate within reasonable limits, the conversion is carried out at 50-60 C. Reaction is almost instantaneous. Sulfonating agent need be used in only 5 per cent excess to bring residual free-oil content within specification (2 per cent max.).

With proper cooling, very short reaction time (8 min) becomes feasible. Upon completion of the reaction, the product is immediately cooled and neutralized with caustic in 10 per cent excess. To remove a brownish coloring, the slurry is bleached by addition of 5 per cent sodium hypochlorite at a pH controlled to 5-11. Typical product assays 1.3 per cent unsulfonated oil, 3.2 per cent sodium sulfate, 95.5 per cent active sodium dodecyl sulfonate.

Dicyanobutene; Adiponitrile

In Part III of this series, we discussed the production of 1, 4-dichlorobutene—2 from butadiene. The importance of this compound rests entirely in its role as intermediate in one commercial route to adiponitrile, raw material for nylon. The conversion is accomplished by following scheme:

$$ClCH_2 - CH = CH - CH_2 - Cl + 2HCN \rightarrow CH_2(CN) - CH\ CH - CH_2 - (CN) + 2HCl \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3a)$$

1, 4 dicyanobutene — 2

$$\xrightarrow{H_2} (CN) - CH_2 - CH_2 - CH_2 - CH_2 - CN \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3b)$$

adiponitrile

The nitrilation-dehydrohalogenation reaction (3a) is carried out in moderately acidic media (pH 4-6). Yields exceeding 80 per cent of theory are attained. The nitrilating agent is hydrogen cyanide. An acceptor base must, of course, be provided to allow for the absorption of hydrogen chloride in situ. The dual demands of maintaining an acidic condition throughout the reaction progress and of minimizing hydrogen cyanide absorption by the acceptor are best served by using an insoluble salt, and calcium carbonate is preferred.

Reduction in nitrilation time can be effected by the catalytic use of copper and its salts (notably cuprous chloride). The amount of catalyst is not too critical but should be at least 0.1 mole-per cent (based on dichlorobutene), and is preferably between 0.5 and 2.0 mole-per cent.

Use of diluents is required to obtain a reaction phase of sufficient fluidity for smooth progress of the reaction. Either organic solvents or aqueous medium may be employed.

Operating temperature is, of course, limited by the boiling point of the system. When water is the chosen diluent, the maximum temperature is, therefore, in the range of 100 C, unless elevated pressures are used.

The rate of hydrogen cyanide addition should be carefully controlled to keep approximate pace with the progress of reaction. Slower addition is unduly time-consuming. On the other hand, very rapid addition will increase the burden on the overhead liquefaction system, which must be provided for unused hydrogen cyanide. The total amount of HCN fed to the system is slightly in excess of stoichiometric requirements (namely, 2 moles per mole dichlorobutene).

An excess of calcium carbonate (the acceptor) is employed to ensure complete removal of evolved hydrogen chloride. Nothing is gained, however, by the use of very large excess.

Operating the reaction in aqueous medium, Farlow[4] employs liquid hydrogen cyanide feed and an overhead condenser that refluxes unused hydrogen cyanide directly to the reaction vessel. The initial feed to the reactor consists of 2000 parts water, 15 parts cuprous chloride, 3 parts copper powder, 3.6 parts concentrated hydrogen chloride, and 6.9 parts potassium chloride.

After the mixture has been heated to 80 C, 525 parts finely powdered calcium carbonate are introduced together with an additional 1000 parts water. With vigorous agitation, the temperature is now raised to 95 c.

The two principal raw materials are added, gradually as a mixture of 625 parts dichlorobutene and 308 parts liquid hydrogen cyanide. Throughout the reaction, the temperature is carefully controlled at 95 C.

Upon completion of the reaction, the liquid product is cooled to 60 C, at which point a small amount of organic solvent (chloroform) is added to prevent crystallization of dicyanobutene. Following further cooling to 25 C, the system is extracted with a large volume of organic solvent and separated from the aqueous phase.

A topping step removes the solvent and final purification is achieved by fractional distillation. Farlow claims a yield of 509.5 parts dicyanobutene (e.e., 95.9 per cent of theory).

Alternate purification methods include recrystallization from benzene.

The feed to the nitrilation stage is an isomeric mixture of 1,4-dichlorobutene-2 and 3,4-dichlorobutene-1. On the other hand, only 1,4-dichyanobutene-2 is a useful intermediate. It is important to note that both of the above dichloro compounds will yield the desired dicyano derivative to the complete exclusion of its 3,4-dicyano isomer, if the nitrilation is carried out in acid medium, i.e. in accordance with the processes described in this article.

Hydrogenation to Adiponitrile. Conversion of dicyanobutene to adiponitrile, in accordance with equation (3b), may be carried out either in the vapor phase or, in the presence of a solvent, in the liquid phase. In either case, palladium on a suitable carrier can serve as catalyst.

Vapor-phase hydrogenation of dicyanobutene is carried out at atmospheric pressure and at 250-300 C. While theoretical requirements call for only one mole hydrogen per mole dicyanobutene, actually a ratio in excess of 10:1 is used to achieve completeness of vaporization and reaction.

At such conditions, conversion over palladium on charcoal is nearly quantitative. There are no significant side reactions.

Romilly[5] has described the liquid-phase hydrogenation of dicyanobutene over fixed-bed supported palladium catalyst (2 per cent metal content).

Space velocities of 0.3-0.6 volumes dicyanobutene per hour per volume catalyst are employed. Elevated pressure (up to 500 psi) is required. Best conversion is obtained between 125 and 150 C.

A solvent must be employed to promote satisfactory catalyst life. Best results are reported for methanol in which dicyanobutene is dissolved in approximately 5 per cent concentration.

At optimum conditions, yields in the range of 95-97 per cent of theory can be obtained in the liquid-phase process. Satisfactory catalyst activity after a life of at least 300 hr has been reported. Regeneration of the catalyst may be effected in a stream of hydro-

gen at 650 C or in nitrogen-diluted air at 200-300 C.

Methyl Ethyl Pyridine

Methyl ethyl pyridine is one of the newcomers among commercial acetaldehyde derivatives. The first plants for its synthesis (operated by Phillips Chemical Company, and Carbide & Carbon Chemicals Company, respectively) came on stream in 1952.

As yet, production volume is relatively small. Combined output of five synthetic MEP producers is estimated near 10,000,000 lb. But MEP synthesis marks the first entry of the petrochemical industries into the production of heterocyclic nitrogen bases, which had heretofore been available only from coal tar refiners.

At present, methyl ethyl pyridine serves chiefly as intermediate in the manufacture of the vitamin component nicotinic acid (by oxidation), and of methyl vinyl pyridine (by dehydrogenation). The latter compound has value as co-monomer in the production of synthetic rubber and of synthetic fibers. In the latter application, the introduction of a small percentage methyl vinyl pyridine into the polymeric chain markedly improves the dyeing properties of the fiber.

Production of MEP involves the reaction of paralydehyde and ammonia (for the trimerization of acetaldehyde to paraldehyde, see Part V of this series):

$$1\tfrac{1}{3}\,(CH_3CHO)_3 + NH_3 \rightarrow \text{(2-ethyl-5-methyl pyridine)} + 4H_2O \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

A number of by-products are formed in the process, among them alpha and gamma-picoline plus higher pyridines.

Feed to the reaction is a mixture of paraldehyde and aqueous (28 per cent) ammonia. Temperature is taken initially to 200 C and raised gradually to 250 C, with an accompanying operating pressure near 300 psi, since liquid phase must be maintained. Total reaction time is 1/1.5 hr.

Frank et al.[6, 7] were able to obtain commercially feasible yields of MEP by the use of a catalyst (ammonium acetate) and high ammonia : paraldehyde ratios. By raising the ammonia feed from 1.17 times to 10.7 times the theoretical amount, these investigators were able to boost yield from 31 per cent to 70 per cent of theory. The use of 3.7 times the theoretical amount ammonia gave a 51 per cent yield of MEP.

In adopting this reaction to commercial operation, Phillips Chemical Company modified the catalyst for the obtainment of even higher MEP yields.[8] In plant operation, the reaction product is flashed for ammonia recovery. MEP is isolated by fractional distillation.

Levy and Othmer[9] have recently reported a modification of the above reaction, whereby pyridine and picolines are obtained in predominance. In this work, ammonia was reacted with a 6:4 mixture (wt basis) of acetaldehyde and formaldehyde. The reaction was carried out in the vapor phase over activated silica-alumina as preferred catalyst.

From the yield point of view, the operating temperature optimum is app. 360 C. Best space velocity is 1.18 g/hr/g catalyst. Yield rises rapidly with increasing ammonia : aldehyde ratio up to 320 per cent excess ammonia. At this point, the curve levels suddenly and further yield improvement with increasing ammonia charge is insignificant.

Overall, Levy charges 31.9 lb acetaldehyde, 21.8 lb formaldehyde, 37.1 lb water and 25.7 lb ammonia to obtain 18.2 lb total pyridine bases. Of this, 5.2 lb is pyridine proper, 2.0 lb is alpha-picoline and 5.5 lb is beta-picoline. Some 40 per cent of the feed aldehydes are found as such in the product.

Nitroparaffins

A process for the production of the lower nitroparaffins by vapor-phase nitration of propane was discovered in the mid-1930's. This method provided a means for the economic production of a whole new family of petrochemical compounds. Commercial Solvents Corporation, owner of the nitration process, built a semi-commercial nitroparaffin plant at Peoria, Illinois. Since then, the plant has been expanded several times, and in August, 1955, Commercial Solvents began operating its first large-scale nitroparaffin plant, located at Sterlington, Louisiana. The new plant is rated at 10,000,000 lb/year nitroparaffins.

The growth of nitroparaffins illustrates how aggressive market development can uncover outlets for a previously unknown chemical. The following table[10] indicates the wide range of industrial applications in which nitroparaffins and their derivatives are consumed today:

Industrial Applications of the Nitroparaffins and Derivatives*

Product and Formula	Application
Nitromethane CH_3NO_2	Solvent for nitrocellulose, cellulose acetate, cellulose acetate butyrate, acrylonitrile polymers, and vinyl resins; synthesis of insecticides, explosives, and photographic chemicals; selective solvent, ingredient of special racing and model engine fuels; propellant.
Nitroethane $CH_3CH_2NO_2$	Solvent for cellulose esters and vinyl resins; raw material for synthesis of pharmaceuticals, insecticides, and surface active agents; ingredient of synthetic finish removers.
1-Nitropropane $CH_3CH_2CH_2NO_2$	Solvent for cellulose esters, vinyl resins and many dyes; raw material for synthesis.
2-Nitropropane $CH_3CHNO_2CH_3$	Solvent for cellulose esters and vinyl resins; raw material for synthesis; heat sensitizer for rubber latex; ingredient of synthetic finish removers.
2-Amino-2-Methyl-1-Propanol $CH_3C(CH_3)NH_2CH_2OH$	Emulsifying agent (in form of its soaps) for floor wax, paints, cleaners, and polishes; stabilizer in urea and melamine alkyd enamels; raw material for synthesis; ingredient of textile, leather, and other specialties.
Tris (Hydroxymethyl) Aminomethane $(CH_2OH)_3CNH_2$	Emulsifying agent in form of its soaps; for synthesis of textile specialties, drying oils, and synthetic resins; analytical reagent.
2-Amino-2-Methyl-1, 3-Propanediol $CH_2OHC(CH_3)NH_2CH_2OH$	Emulsifying agent in form of its soaps; raw material for synthesis; ingredient of textile specialties.
Hydroxylammonium Acid Sulfate $NH_3OH.HO_2SO_4$	Effective reducing agent, especially for metal ions; useful raw material for synthesis of pharmaceuticals, dyes, rubber and photographic chemicals and synthetic fibers.
Hydroxylammonium Sulfate $(NH_3OH)_2.H_2SO_4$	Reducing agent, especially for metal ions; reagent in dyeing acrylic fibers; for synthesis of pharmaceuticals, rust and polymerization inhibitors, dyes, rubber, and photographic chemicals; nondiscoloring short stopper for polymerizations.
Alkaterges C, A, E, T	Oil-soluble surface-active agent, emulsion stabilizer and acid acceptor; pigment grinding aid and dispersing agent for solids in organic liquids; antifoam agent; useful in metal cleaners, polishes, and lubricants.
Diamines $(CH_3)_2CNH_2CH_2NHCH(CH_3)_2$ $(CH_3)_2CNH_2C_6H_5NHC_6H_5$ $(CH_3)_2CNH_2CH_2NHC(CH_3)_2CH_2OH$	Curing agents for epoxy resins, alkaline catalysts, stabilizers for melamine and other resin finishes, dye intermediates, and in the manufacture of pharmaceuticals and surface active agents.

*Courtesy: Commercial Solvents Corporation.

Manufacturing Process for Nitroparaffins

Synthesis of mixed nitroparaffins is accomplished by vapor-phase reaction of lower hydrocarbon (in this instance, propane) and nitric acid. Best product yield is attained between 390 and 440 C and at high-hydrocarbons nitric acid ratio. Ideally, a ratio as high as 20:1 is desirable, but practical considerations limit this value to about 6:1.

The nitration reaction is highly exothermic and very rapid. In the original approach of pre-mixing and reactants prior to entry into the converter, it was not found possible to hold the temperature within the fairly narrow operating limits, which are defined above for optimum performance. To overcome this problem, alternate approaches to reactor design have been investigated, among them the use of a fluidized-solids system. The preferred converter, which has been adopted at Sterlington, is of the multiple-acid-spray type.

In this design, the nitrator consists of several sections of vertical cylindrical tube. Preheated propane is introduced to the reactor top. Between ni-

trator sections, the process stream is joined by an atomized spray of liquid nitric acid. Several such sprays exist (up to a practical total of five), and the total acid feed is distributed between them. By choosing the proper concentration of nitric acid, such a system in which the exothermic heat of reaction is balanced by the heat of vaporization of acid and in which temperature fluctuations are held between the desired limits (390 to 440 C). At the same time, the ratio of hydrocarbon to unconverted acid can be held very high at any one point without exceeding the conventional limits in overall feed ratio.

In a reasonably adiabatic converter system, thermal balance is attained by the use of 75 to 78 per cent nitric acid. With this concentration, five additions are used to best advantage.

Stengel and Egly[11] have reported the use of such a multiple-acid-spray system in the nitration of propane. Each converter section was 3-in. diam by 6 ft long. Five sprays of 78 per cent cold nitric acid were employed. System pressure was 125 psi. Propane was fed to the reactor top at 11,500 cfh and at a preheat temperature of 430-435 C. Nitric acid injected to the first stage gave a local reactants' ratio of 24.2:1. Since five such sprays were used in series, overall ratio was 4.84:1. In this system, the temperature range was 400 C just below each nitric acid feed point and 425 C at the exit from each section (if necessary, the addition of a small amount of steam may serve for assistance in quenching). In this reaction, product yield was 169 lb/hr nitroparaffins of average molecular weight 83. Conversion, based on nitric acid, was 30.8 per cent.

In current commercial practice, typical distribution of products from propane nitration is 25 per cent 1-nitropropane, 40 per cent 2-nitropropane, 10 per cent nitroethane, and 25 per cent nitromethane. This is not necessarily the ideal proposition from the point of view of market requirements, and means have been sought for the independent control of product ratio. At the same time, research has been strenuously directed at the improvement of yield.

Information has been accumulated that both purposes can be served by the use of vapor-phase catalysts, notably oxygen, chlorine, and bromine. The favorable effect of oxygen addition on yield of useful product has been the subject of a fairly early patent by Hass. More recently, Bachman[12] has ascribed an even greater yield advantage to the addition of small amounts of chlorine to the vapor-phase nitration system.

Bachman and Pollack[13] have made a significant study of the effect of such catalysts on product distribution. They were able to show that the formation of higher products (i.e., nitropropanes) was favored by the addition of chlorine, while nitration of propane in the presence of oxygen led to more extensive formation of the degradation nitration products nitromethane and nitroethane. By judicious adjustment of the amount in which oxygen and chlorine were added, these investigators were able to control each of the four main products with a fair degree of independence within wide limits:

	Conversions, per cent	
Nitroparaffins obtained	Maximum	Minimum
Nitromethane	49	9
Nitroethane	36	6
1-Nitropropane	35	9
2-Nitropropane	45	5

In recent years, there has been active accumulation of additional information on the production and chemical utilization of nitroparaffins. For the sake of the reader's convenience, reference is made to some further recent publications of outstanding interest in this field.[14]

* * * * *

This concludes our survey of petrochemical techniques employed in the conversion of ethane, propane, and butanes to their most important derivatives. Obviously, such a study cannot be exhaustive regardless of space allotted to it. The field is immense and reaches into almost every phase of the chemical process industries in one way or another. But, even more significantly, this part of the industry is today in a highly dynamic phase. Already, there have come to this writer's attention new developments of important potential, which were still insufficiently defined when the first parts of this series were written. Such new knowledge may be dealt with in a subsequent paper.

But the grand pattern of this branch of the industry is firmly founded, and the present report has covered its highlights.

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★ ★ ★

"They tell me some of our achromobacter cruciviae bacteria broke outa the phenol oxidation bed — you ain't one of 'em are you?"

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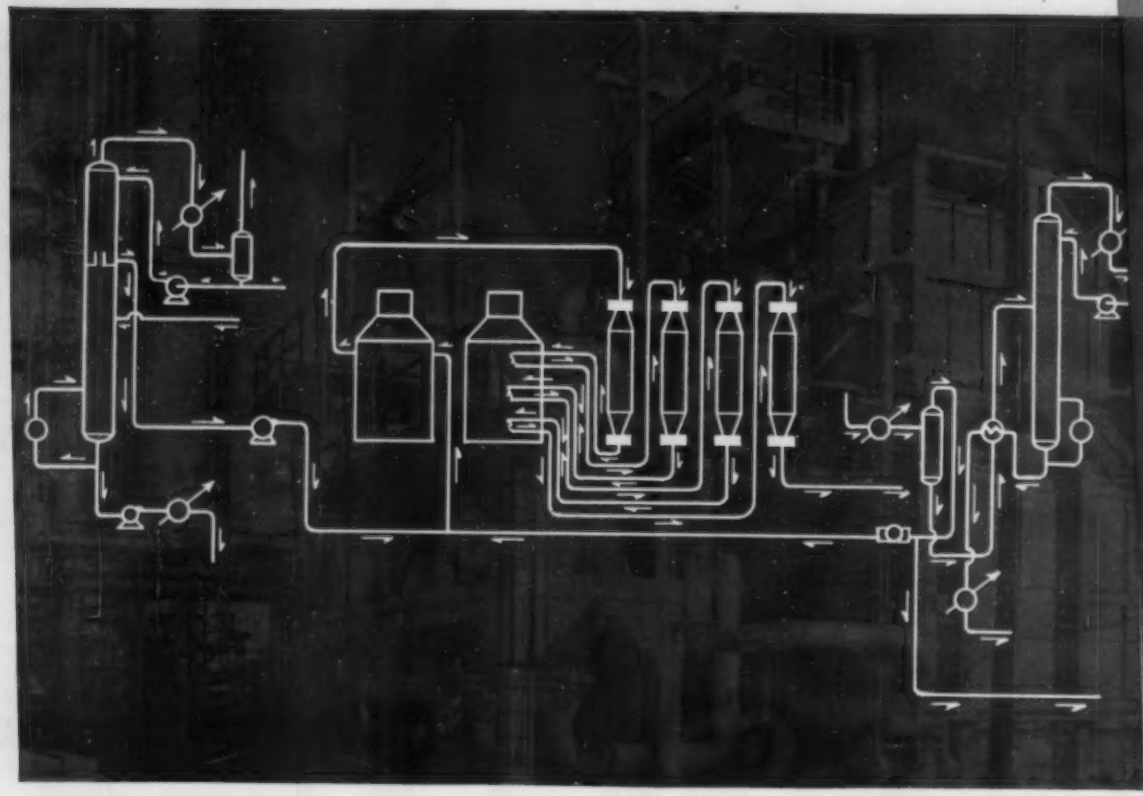

Simplified flow diagram of Platforming Process

Platforming, developed by UOP and introduced in 1949, pioneered the use of platinum in a catalyst for refining gasoline and is today one of the world's most widely used processes. Early in its development, our research team realized that Platforming offered a practical means of helping meet the chemical industry's growing demand for aromatics. Experimentation indicated that, by employing certain modifications in operating conditions, high yields of aromatics were possible through Platforming. This was only a partial solution because the problem of separation of aromatics in the degree of purity required by the chemical industry still remained.

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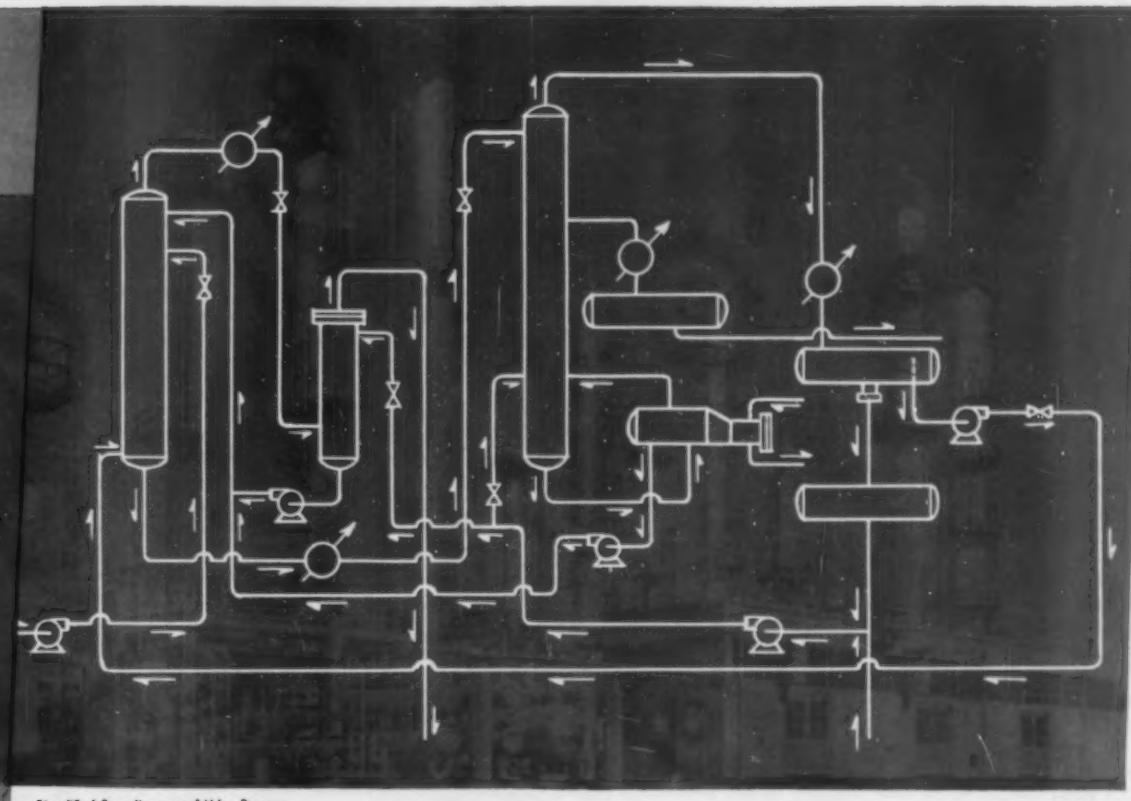

Simplified flow diagram of Udex Process

Udex, developed by Universal in cooperation with Dow Chemical Company, provided the answer. It successfully created and applied the separation equipment necessary to concentrate the aromatic hydrocarbons produced by Platforming into the form required by the chemical industry. This combination of UOP's Platforming and Udex processes, an outcome of a basic research program originally directed toward motor fuels, is an outstanding example of the broad scope of UOP research.

Universal research is continuing to develop and make available to all refiners, everywhere, not only new and improved processes for producing more efficient fuels for automotive engines, but also better ways of utilizing by-products from petroleum. In this way we believe we are truly helping the refiner to get the most out of every barrel of crude.

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II. SELECTING EQUIPMENT

B. Tubular Heaters Air Preheaters Tube Cleaning

Section 5

L. A. Mekler
Consulting Engineer

Most of the process heaters built in the last few years are designed for thermal efficiencies of 65-75 per cent of the L.H.V. of the fuel and consist of a radiant section, which absorbs 60-80 per cent of the load and a convection section, which absorbs the remainder.

Generally, bare tubes are used in the convection section and the average heat input rates for the total section vary between 3000 and 5000 Btu/hr/sq ft of circumferential outside surface, depending on the temperature of the gases leaving the radiant section and the approach between the inlet temperature of the charge and the outlet temperature of the gases. The 3000-5000 Btu rates are exclusive of the shock banks.

In most heaters, the shock banks are considered a part of the radiant bank and have rates equal to or exceeding those in the radiant tubes. In heater K, the upper portion of the radiant tubes, used as the convection section, is provided with sufficient fin or stud-extended surface to obtain heat-input rates based on bare outside surface, close to the average rates in the radiant bank. In the convection section of heater J, the extended surface is normally designed to give average bare-surface rates of 65-85 per cent of the rates in the radiant bank.

With fuel cost below 15 cents/MM Btu, heaters with a well designed convection section can give the lowest overall processing cost so that the use of air preheaters for the sole purpose of obtaining higher efficiencies and lower fuel costs than can be obtained with a convection section is seldom justified. Quite often, however, an air preheater is used for other reasons. If the charge is corrosive through the range of lower temperatures of the heating curve and requires alloys in the convection section, and the fuel is relatively non-corrosive so that carbon or low-alloy steel can be used through the major portion of the preheater, a heater with an air preheater and a small convection section may give lower overall processing costs than a heater with a convection section only. In addition to lower fixed charges and maintained costs, the heater with an air preheater can be made 5-10 percentage points more efficient than the heater with a full convection section. Some charging stocks have a tendency to polymerize when heated at low rates through the lower temperatures of the heating curve and to form coke from the polymers when heated through the high-temperature range of the curve. Replacing the major portion or all of the convection section by an air preheater, so that the charge is heated quickly through the polymerizing range of temperatures in radiant or shock tubes, may be desirable in this case from purely process consideration, even though the overall processing costs of the heater with an air preheater are higher than of an equivalent heater with a convection section.

As a general rule, most "off-standard" gaseous and liquid fuels, and particularly the pitch-like residues, can be burned with less excess air, better flame characteristics and a more definite pattern of flow of the main stream of gases through the heater in burners designed for forced draft and preheated air. A constantly increasing number of heaters are now being built with air preheaters, primarily for this reason. Usually the shock bank only, or a small convection section is used in conjunction with an air preheater to lower the temperature of the gases entering the preheater and to reduce or eliminate high-temperature alloys at the hot end of the preheaters.

Use of air preheaters for purposes other than fuel savings may still produce appreciable savings where the temperature of the gases leaving the heater cannot be reduced below 1000 F by a convection section of economical design. Fig. 18 shows the saving obtained with air preheated to 500 F and 700 F by 1000 F and 1200 F gases and to 700 F and 900 F by 1400 F gases. The savings are based on the fuel requirements with a given gas temperature and excess air without air preheat. For example, from lines B and C, with 1200 F gases and 20 per cent excess air, preheating the air to 500 F and 700 F gives savings of approximately 13 and 19 per cent of the fuel required with 1200 F gases and no air preheat. The curves on Fig. 18 can serve as a guide as to the order of magnitude of saving obtained on heaters with a radiant section only, (1400 F gases), heaters with a shock bank, (1200 F gases), and heaters with a small convection section, (1000 F gases). In each case, the savings are affected only slightly by an increase in excess air because the higher stack gas losses with the higher excess air are compensated to a great extent by the heat recovered in the additional air used. This is one of the secondary advantages of air preheaters, since with them it is possible to increase the excess air by 10-15 percentage points, if necessary to clean up the flames, without appreciably affecting the thermal efficiency of the heater. Normally with a small increase in excess air, there is no appreciable drop in air preheat because with the higher velocities through the preheater the heat transfer coefficient may be sufficiently increased to compensate for the higher heat load.

Air preheat increases the flame burst temperature and, because of higher efficiency, decreases the heat liberation per square foot of "effective heat absorbing area" of the heater, which makes the radiant heat absorbing surface more efficient. Fig. 19 shows the relationship between the flame burst temperature, heat liberation, and the radiant heat absorption per square foot of "effective area" at different temperatures of the absorbing surface. The "effective area" is the equivalent "black body" area of the radiant section and is equal to the projected area of the tube

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What the Press says about the Tanker

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N. Y. HERALD TRIBUNE
APRIL 9, 1956

World Glory makes seventeen-knots loaded on 15,000 horsepower, using eighty-three tons of fuel daily.

"This unrivalled efficiency was an important factor in the decision to build the new ship for American flag operation. In the last two years, other tankers of 45,000 tons and more have been built abroad, but this is the first time that one of these mammoth ships will join the American merchant marine."

NEW YORK TIMES
APRIL 9, 1956

Three vessels are to be built in this country and will be registered here. In addition to the super tanker, orders have been placed for two more at 32,000 tons each.

The Niarchos tanker World Glory, slightly smaller than the present ship, was built at the same yard, but for foreign registry. The new vessel's design closely follows the World Glory's. The latter's extraordinary efficiency has attracted great attention. On 15,000 horsepower she develops seventeen knots, using only eighty-three tons of fuel a day.

N. Y. HERALD TRIBUNE
APRIL 17, 1956

The 46,000-ton tanker will be slightly larger than the World Glory built by the same Bethlehem yard for Mr. Niarchos who is operating it under the Liberian flag. The World Glory has established a remarkable record since she went into service two years ago for reliability and economy of operation.

NEW YORK TIMES
AUGUST 26, 1954

The World Glory is very fast afloat and smooth in operation. Her 15,000-horsepower turbines turned out speeds in excess of seventeen knots in all-out trial runs last May, and she managed to better sixteen knots while using only 12,000 horsepower.

Master Is a Veteran

The master of the World Glory, Captain Corcacas said she had handled "like a baby carriage" on her initial trip.

NEW YORK TIMES
MAY 4, 1954

After the vessel docked shortly after 2 P. M. at the Boston Naval Shipyard in East Boston, Captain Smith praised the performance of the tanker, the second largest merchant ship built in this country. The 53,000-gross-ton superliner, United States, built at Newport News, Va., is the largest.

"She performed marvelously," he said.

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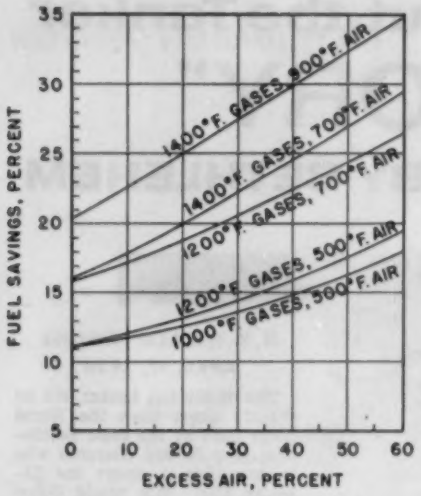

FIG. 18. Saving obtained with air preheat.

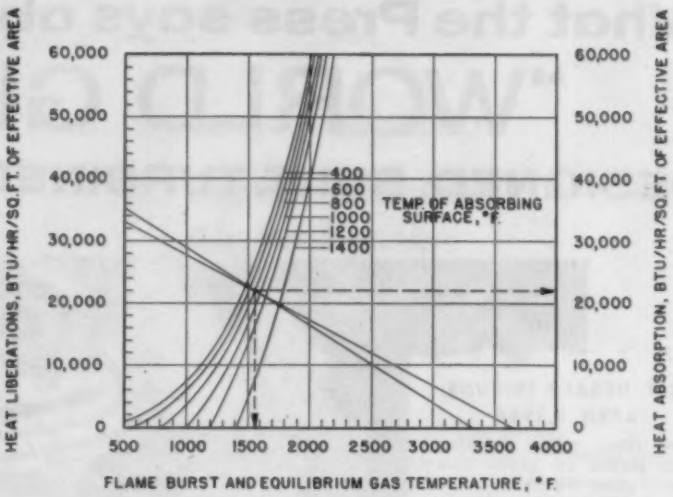

FIG. 19. Relationship between heat liberation and radiant heat absorption with different flame burst and absorbing surface temperatures.

banks, including the space between the tubes, multiplied by the effectiveness factor of the banks, (0.7 - 0.90, depending on tube spacing) and by the overall emissivity of the radiant section (0.7 - 0.95, depending on the geometry of the heater). On a tube spacing of two diameters, the effective area is equal to approximately one-third of the circumferential surface of the tubes in heater F, and is slightly over one-half of the circumferential surface in heaters G, J, and K. The greater the ratio between the effective area and circumferential surface of the radiant banks the more efficient are the banks as radiant heat absorbers.

Table 6 shows a comparison of performance characteristics of radiant banks in the same heater with and without an air preheater. One of the items on Table 6, the flame burst temperatures, may appear inconsistent in that with an air temperature increase of 640 F, the flame burst temperature is increased only 350F, Some of the difference is due to the higher specific heats of the products of combustion at the flame burst temperature than of air at air preheat temperatures, and to the greater weight of combustion products than of air, but most is caused by the rapidly increasing disassociation of CO_2 and H_2O at temperatures above 3100 F, so that as the flame burst temperature is increased, a constantly increasing portion of the heat content of the products is lost by disassociation. With 1000 F preheated, the calculated flame burst temperature would be raised only by 425 F and with 1200 F air by only 475 F. Recent experimental measurements indicate that the actual flame burst temperatures obtained with air preheated above 500 F are considerably lower than the calculated. The heat of disassociation, which appears as lost at flame burst temperatures, is converted to sensible heat when the temperature of the gases drops below 3100 F, so that all of the heat brought in by air preheat is recovered in the heater.

TABLE 6. Radiant Heat Absorption Characteristics of Heaters With and Without Preheated Air.

	Without air preheater	With air preheater
Gas temperature leaving heater or entering air preheater, F	1,200	1,200
Air temperature, F	60	700
Calculated flame burst temperature, F	3,325	3,675
Liberation, Btu/hr/sq ft of effective area	40,000	37,000*
Radiant absorption, Btu/hr/sq ft of effective area	22,000	22,000
Equilibrium gas temperature, F	1,560	1,560
Absorption, per cent of total liberation	55.0	59.5
Radiation loss, per cent	2.0	3.0
Thermal efficiency, including radiation loss	68.4	82.7
Absorbed in air preheater, per cent of liberation	0.0	15.3
To be absorbed in convection section, per cent of liberation	13.4	7.9

* Includes heat brought in by preheated air.

Air preheaters of the recuperative plate and tubular type were used quite extensively in the 1920's as a necessary adjunct to flue gas recirculation where the temperature of the gases leaving the heater was usually above 1100 F. In recuperative preheaters, the heat is constantly supplied to the plates or the tubes on one side and is constantly withdrawn by the gases on the other side. Recuperative air preheaters are now seldom used on new heaters and many of the recuperative air preheaters on existing heaters are being replaced by the rotary regenerative type. In regenerative preheaters, the heat from the gases is first absorbed and stored in the elements, while the elements are in the gas stream, and then given off to the air, while the elements are in the air stream. The elements are reheated or "regenerated" every cycle.

Fig. 20 shows a general assignment of a rotary regenerative air preheater used on many process heaters. The preheater consists of a rotor filled with corrugated, thin-plate elements that give a large surface to mass ratio of metal. The rotor revolves at 3-5 rpm through adjoining gas and air ducts so that a part of the rotor is always in the path of the gas stream and another part in the air stream, usually with countercurrent flow of gases and air. Two small segments of the rotor separate the gas and the air portion of the rotor and are used to seal off the two streams from each other by seal strips attached to the rotor.

In the past, most rotary preheaters were equipped with two fans, a cold air or forced draft to force the air through the preheater and the air ducts, and an exhaust-gas or induced-draft fan to pull the gases through the heater and the preheater. In some recent installations, only the forced-draft fan is used, and the setting and ductwork are made air tight to permit operation with a positive pressure through the system.

Fig. 20 shows the rotor revolving with the axis in a horizontal plane. Substantially the same arrangement is used in air preheaters with the axis rotating in a vertical plane. The choice between the two types of rotation depends on the geometry of the heater and the ductwork from the gas outlet of the heater to the air preheater and from the air preheater to the burners. With non-corrosive fuels and gas temperatures entering the preheater below 1000 F, all elements of the preheater are of carbon or low-alloy steel. With higher gas temperatures and corrosive

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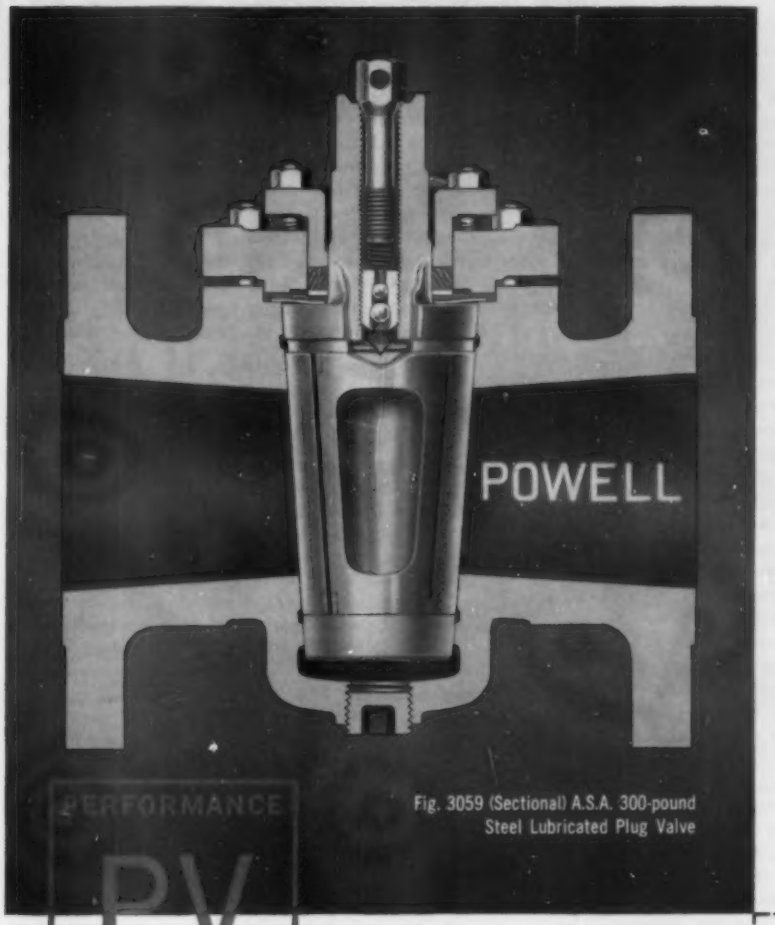

Fig. 3059 (Sectional) A.S.A. 300-pound Steel Lubricated Plug Valve

FIG. 1559G—150-pound Steel Lubricated Plug Valve. Gear operated

FIG. 2200—175-pound W.O.G. Semi-Steel Lubricated Plug Valve

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fuels, the elements are made up in two or more sections longitudinally, with temperature and oxidation-resistant alloys on the hot end and copper-bearing, low-alloy steel on the cold end. Fig. 21 shows a rotor with two-section elements.

While rotary, regenerative air preheater can be designed for recovery of up to 75 per cent of the heat content of the gases, the heat recovery is usually limited to give a gas outlet temperature between 400 F and 500 F, to prevent condensation of the corrosive gas constituents at the cold end. Preheaters with multi-section elements are arranged for easy replacement of the sections subject to most wear. Many process heaters operate with normal runs from 6 to 18 months. Where due to dirty or highly corrosive fuel the elements must be cleaned or reconditioned after such long runs, the complete rotor is replaced by a spare and the removed rotor readied for the next run at leisure between shut downs.

Auxiliaries

The principal auxiliaries of process heaters are platforms, peepholes, regular and emergency dropout and snuffing out lines, and means for decoking the tubes.

Platforms and Peepholes

In horizontal tube heaters with cleanout plugs in the headers, the platforms are used mainly to facilitate cleanouts. In heaters with vertical tubes, fired through the floor or the roof, additional platforms are used for access to peepholes to observe the burners and the tubes. Quite often the firing valves for the individual burners are located at the intermediate platforms so that they serve also as firing platforms. Generally, the same set of peepholes is used for the burners and the tubes, but sometimes this is not the best arrangement. In heater G, usually a multi-cell heater, peepholes that can be located only in the end walls (in planes parallel with the paper) give the best visibility of the tubes, while peepholes close to the vertical bank are better for observing the burners. In heaters J and K with long tubes, the portion of the tubes near the base of the cone cannot be seen from peepholes at the firing platform, and peepholes in the floor are usually added for looking at the upper portion of the tubes. All peepholes are best located off-side the nearest burner so that the visible flame from the burner does not obscure the view.

Snuffing-Out and Drop-Out Lines

Process heaters are usually equipped with two independent systems of steam snuffing-out lines — local, manually controlled lines to the header boxes to stop a small fire due to a leak in the headers, and emergency remote control lines into the combustion chamber. Header boxes and the inlet to the air preheater, if used, admit large quantities of steam in case a tube ruptures. In heaters where the convection section and an air preheater are equipped with soot blowers, the soot blowers are usually interconnected with the emergency steam system.

The number and location of drop-out lines depend on the geometry of the heater structure and the arrangement of tube banks. Normally, the drop-out lines are connected to the lowest points in the tube banks. Where the lowest points are in the portion of the coil most susceptible to coking, so that the drop-out valves may coke up during a long run, the drop-out lines are moved to the nearest non-coking location and extra steam is used to blow out the tubes in the low pocket. For emergency drop-outs, the valves are usually provided with remote hydraulic or pneumatic operation with a trigger-like hammer blow at the start to loosen the valve off the seat.

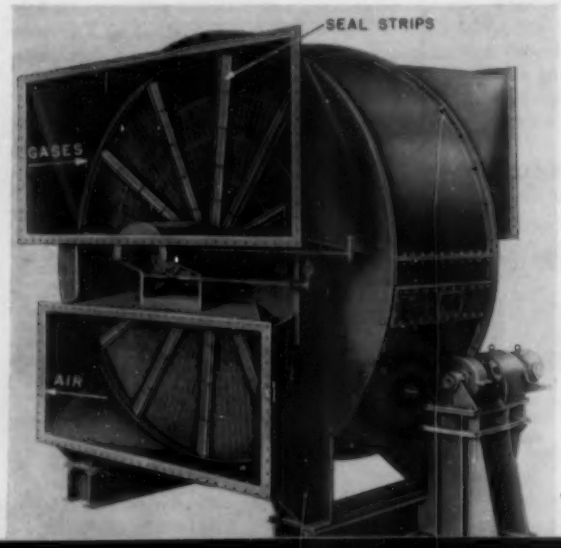
Tube Cleaning

Two methods are used to clean deposits in the tubes — turbining and steam-and-air decoking. Turbining is the older method and can be used only on tube banks with clean-out plugs. At present, even with such banks, turbining is used only where the coke formed is relatively fragile and does not adhere tenatiously to the tubes. Turbining does not require any particular skill and with fragile non-adhering coke in the tubes and heavy deposits in the return bends, turbining may be completed as quickly, or quicker, than steam-and-air decoking, if a number of clean-out crews can be effectively used at the same time. The two main disadvantages of turbining are the noise, which is objectionable near populated areas, and possible damage to the tubes by prolonged over-turbining in one spot. Even a slight overturbining may do some harm by roughening the inside surface of the tubes, which will make the coke more adherent to the tubes and make the next cleanout more difficult.

Steam-and-air decoking is gaining in popularity and is used not only for coils without clean-out plugs, which can be cleaned only by this method, but also on coils with plugs where the coke is thin, tough and resilient, so that instead of being broken off the tube, it has to be ground off, or where the plugs are hard to make tight after unheading. Steam-and-air decoking is as yet somewhat of an art and depends more on the skill and judgment of the operator than on explicit instructions for procedure. It is not unusual for a heater to decoke differently from run to run so that a so-called "standard" procedure often serves only as a general guide.

Fig. 22 shows a schematic piping arrangement for steam-and-air decoking that consists primarily of means for controlling the flow of steam and air to the coil, measuring the temperature of the effluent from the coil and quenching the effluent with water before it is discharged into the sewer. If the coil is equipped with thermocouples on the outlet and the inlet, and the blank-off flanges are beyond these thermocouples, they can be used instead of those shown on Fig. 22. The discharge line is provided with a sample line for observing the progress of decoking as indicated by the color of the effluent and the size of coke particles. In heaters with multiple streams in parallel, separate hookups are required for each stream. With long coils, an intermediate point in the coil is connected to the hookup so that the coil can be decoked from the inlet and outlet towards the intermediate point, or from the intermediate point towards the inlet and outlet. Usually the piping and instruments as shown on Fig. 22 are assembled into a permanent manifold that is moved from heater to heater. Some heaters have the steam-and-air decoking piping as permanent equipment.

FIG. 20. Rotary regenerative air preheater.



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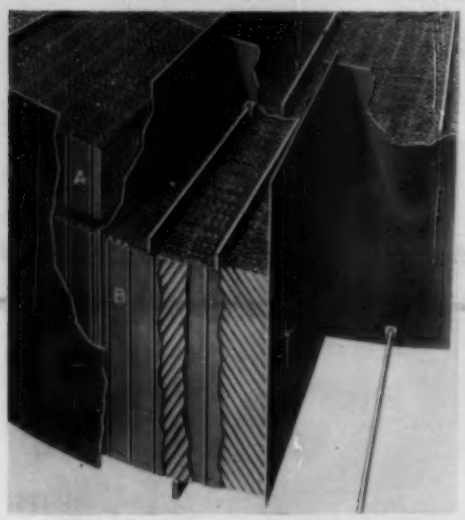

FIG. 21. Two-section elements rotor of regenerative air preheater: A—high alloy; B—low alloy or carbon steel.

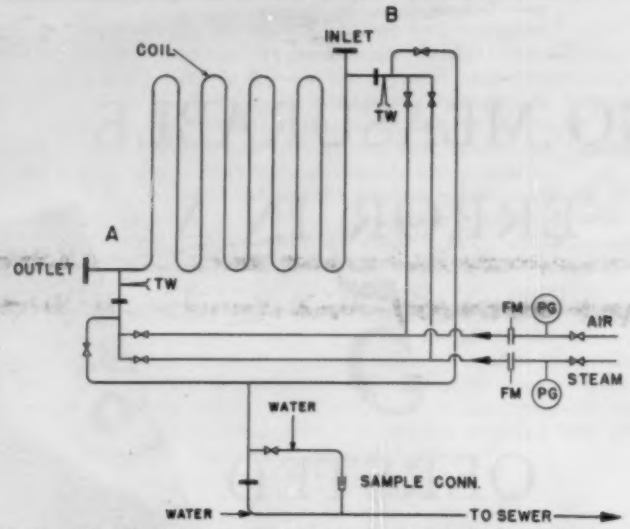

FIG. 22. Schematic arrangement for steam-and-air decoking.

Steam-and-air decoking depends on three mechanisms.

1. Spalling, produced by differential expansion between the metal and the coke.
2. Oxidation of the coke with air.
3. The water gas reaction between steam and coke. The water gas reaction is important only in high-temperature heaters with austenitic tubes where the furnace and effluent temperatures are over 1400 F.

In steam-and-air decoking, the major portion of coke is removed by spalling. At the start, the tubes are maintained hotter than the coke. A sufficient number of burners are lit, at not more than half capacity, to bring the furnace temperature, as measured near the point where the gases leave the radiant section, to 1200 - 1300 F with ferritic tubes and to 1450 - 1550 F with austenitic tubes. Steam is introduced into the coil when the furnace temperature reaches 700 - 800 F with ferritic tubes and 1000 - 1100 F with austenitic tubes. The amount of steam and the rate of firing are increased until 450 - 500 lb of steam per square inch of inside area of the tubes is passing through the coil and the temperature of the steam leaving the coil is 900 - 1100 F for ferritic tubes and 1350 - 1450 F for austenitic tubes. Spalling usually starts before these temperatures are reached. With a normal rate of spalling, the effluent, as observed through the sample line, is dark gray in color and the coke particles are not over 1/16 in. in size. If the color of the effluent verges on black and the coke is coarser than 1/16 in., decoking is slowed down by reducing the flow of steam or the rate of firing, or both, to prevent erosion of the return bends and the ends of the tubes by high concentration of coarse particles in the effluent.

When the effluent becomes light gray, bordering on colorless, a reversal of the flow of steam through the coil is usually tried before adding air to the steam. Generally, 5 - 10 cfm of air per square inch of inside cross section of the tube is required to maintain the proper rate of burning. Burning raises the temperature of the coke above the temperature of the tubes, which initiates the second state of spalling. The portion of the tube where coke is being burned becomes hotter than the rest of the tubes, and as the burning progresses, the hot spot travels along the length of the tubes. During this stage of decoking, the length of the hot spot and the rate at which it travels along the tubes is a more important indication of the rate of decoking than the color of the effluent, and the rate is controlled by increasing or decreasing the amount of air admitted with the steam. When no further spalling is obtained by reversing the flow through the coil or by increasing the proportion of air in the steam-and-air mixture, the decoking is complete. With ferritic steels, a clean decoking is often indicated by the appearance of fine iron oxide dust in the effluent, which gives it a brownish rather than a grayish color. In some plants, at the end of decoking, air with a small amount of steam is passed through the tubes to form a thin oxide deposit on the inside of the tubes, which tends to reduce coke adhesion to the tubes and helps decoking during the next cleanout.

A process heater is a tailor-made piece of equipment for a specific purpose. It is very seldom when an exact duplicate of an existing heater can be installed in another plant or even on a subsequent unit of a given process in the same plant, without sacrificing some advantages. Because of this, there is always some conflict between the mechanical designer, who cherishes the hope, seldom fulfilled, of developing a standard design for a given service that can be taken "off the shelf," and the process engineer and the operator, who insist on certain modifications that they deem necessary for best results at their plant. The final design is usually a compromise. The author hopes that this article may help to evaluate the local requirements in terms of basic principles and standard practices of mechanical design of process heaters.

Ackowledgment

The author wishes to thank the Petro-Chem Development Company, Inc., for permission to use some of its engineering and operating data in this article, and the manufacturers of the different mechanical components of process tubular heaters for their assistance by publications and private communications.

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DU PONT

PETROLEUM CHEMICALS DIVISION NEWS

DU PONT

October ★ One of a Series of Bulletins for the Petroleum Industry ★ 1956

Merchandising Opportunities in Improved Oils

With the "super premium" gasolines so much in the news, there's an especially good marketing opportunity for premium motor oils.

Consider, for example, an oil with low-duty detergency for stop-and-go driving. The majority of American passenger-car driving consists of trips shorter than 10 miles. And more than 90% of all city bus, taxi and delivery truck operation is in stop-and-go city traffic. These low-power, low-temperature operating conditions, of course, are likely to result in excessive build-ups of engine sludge. This means that there is a considerable market for a new type of lube oil with low-duty detergency.

New polymeric additives

To give oil this property, Du Pont has developed two synthetic detergents... Lube Oil Additives 564 and 565. Both are ashless polymeric additives, slightly basic, that provide an economical and effective means of preventing engine oil sludge – particularly under low-duty, stop-and-go driving conditions. And these additives are effective V.I. improvers as well as detergents.

Any of our sales offices will gladly supply additional information, and a suggested promotion kit.

Additives prevent many oil-burner troubles

With the heating season just getting under way, many old familiar oil-furnace problems will be back to cut, unnecessarily, into fuel distributors' profits through another season.

Plugged nozzles, screens and filters; gel-clogged lines; ignition and stack control failures may all have been part of a day's work for distributors and servicemen last year. But this year can tell a different story. Here it is . . .

When heating-oil is sold on a service-contract basis, every service call costs the supplier money, obviously. This of course comes out of profits. Fortunately, however, many of these common headaches can be prevented with minute quantities of low-cost Du Pont additives.

To prevent sludge . . .

Du Pont Fuel Oil Additive No. 2 (FOA-2) is a double-action additive that works effectively both as a dispersant and as a stabilizer.

It minimizes the formation of insoluble residues. It also helps to rid dirty systems of sludge deposits previously accumulated, by reducing the size of the sludge particles so finely that they do not clog screens or nozzles. In this way, it can actually help reduce the man hours required for distributors' service calls.

Why many railroads prefer economy fuels stabilized with Du Pont FOA-2

Fuel specialists and purchasing agents of many railroads are taking a keen interest in the use of Du Pont Fuel Oil Additive No. 2 (FOA-2) for stabilizing all their economy grade diesel fuels.

Uniform results in a variety of different fuel stocks are a big reason.

Since diesel fuels—especially economy grades – vary widely in their response to additive treatment, you can readily see why such uniformity is an important advantage to the railroads which often have a number of different suppliers loading into the same tank.

After carefully testing economy fuels with a number of different additives for several years, it has been found that FOA-2 gives good results over the widest range of varying fuel stocks. Because of its outstanding stabilizing and dispersant action, FOA-2 helps to cut maintenance costs by relieving filter-plugging and injector-sticking problems. Moreover, the additive does not contribute to the sparking problem which may accompany the use of economy diesel fuels.

If you would like more detailed information about on-the-railroad results obtained with FOA-2, just get in touch with one of our representatives.

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OVER

PETROLEUM CHEMICALS DIVISION
NEWS

CONTINUED *Heating Troubles*

To keep electrodes and stack controls clean . . .

As distributors well know, a number of burner failures are due to insulating deposits on the stack controls and ignition electrodes. Because FOA-2 is a nonmetallic, *ashless* additive, it leaves no deposit to insulate electrodes . . . or to interfere with the operation of control mechanisms.

Du Pont FOA-2 helps prevent nozzle plugging

To prevent gel-clogged lines

Du Pont Metal Deactivator (DMD) can be used effectively to prevent *copper* fuel lines and filter screens from playing mischief with the chemical composition of heating oils. When unchecked, the copper is likely to cause the formation of a gelatinous substance . . . and complete stoppage of fuel flow.

DMD can be economically used in combination with FOA-2. When the two additives are combined, the DMD frequently carries part of the stabilizing load—thus reducing the amount of FOA-2 that is needed for sludge prevention.

For best results

FOA-2 and DMD should be added to freshly prepared stocks at the refinery. For more detailed information on the use and performance of these additives, just get in touch with one of our representatives at any of the sales offices listed below.

ASSISTANT DIRECTOR IN CHARGE OF PRODUCT EVALUATION

Dr. Robert H. Blaker joined the Du Pont Petroleum Laboratory in 1953 as research supervisor, became head of the Combustion Division in 1954 and was appointed assistant director in charge of product evaluation in February of 1956.

Dr. Blaker joined Du Pont in 1950 as research chemist at Jackson Laboratory, where he also served in the Petroleum Division, after an initial assignment in synthetic fiber dyeing.

Berea College awarded Dr. Blaker an A.B. degree in chemistry in 1942. He also attended M.I.T. and received his Ph.D. in physical chemistry at California Institute of Technology in 1949. Dr. Blaker also studied in Britain under an Imperial Chemical Industries grant.

He is a member of the Society of Automotive Engineers and the Petroleum Division of the American Chemical Society.

DR. ROBERT H. BLAKER

New findings on fuel performance in high-compression engines

How much will compression-ratio increases boost octane requirements?

Not necessarily as much as has been generally thought—according to the results of recent studies at the Du Pont Petroleum Laboratory.

Our tests showed that the engine-design, fuel and lubricant, *all* have a significant bearing on engine-performance. This indicates that octane requirements of high-compression engines can be kept at a minimum by careful attention to *each* of these three factors.

A surprising development was noted in one car operated at an 11:1 C.R. Running under normal conditions, this car was found to be free of combustion noise, even on a 100 octane fuel.

It was found that the 90% distilled point is not necessarily the criterion for measuring deposit-harm of fuels. This can mean that there will be more latitude in blending the components for high-compression fuels; more heavy ends may be used in this type of fuel, without detrimental effects on the engines.

The tests also indicate that octane requirements of high-compression engines can be reduced by improvements in lubricants and through engine design.

A paper with full details on this testing program was recently presented at the API Refining Meeting in Montreal. Just drop us a line if you would like a copy.

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A-2718

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REFINING IN BRIEF

Carbon pistons and rings in compressors, perforated plate towers for absorber and depropanizer used in reforming outside-desulfurized naphtha charge

What Happens In a Cat Reformer?

G. F. Eisele and R. Smith
Pure Oil Company

NINETEEN months operation of the first commercial unit using Sinclair-Baker catalyst is summarized. This is a moderate platinum content, regenerative catalyst of high life expectancy developed by the Sinclair Research Laboratories and Baker & Company. Research work done by Sinclair and by sales agent M. W. Kellogg should be recognized.

The unit charges 250-400F naphtha cut from an atmospheric distillation column at an adjoining crude still. Product gas is passed through an absorber using fresh feed as lean oil for recovery of any butanes and heavier, and some deaeration and dehydration of feed is effected. Except for the cobalt molybdate desulfurizing step employing heat pickup by exchange only, flows through the unit are conventional. Feed contains 40-45 per cent naphthenes and 0.03 wt per cent sulfur. Research octane is 40 clear. The desulfurizer reduces total sulfur to 0.005 per cent. Desulfurized naphtha carries some hydrogen sulfide into the reforming section proper.

Piping and equipment above 500F is 2 per cent chrome 0.5 per cent moly steel and several exchanger shells are 5 per cent chrome. Reactors are carbon steel, internally lined to keep operating metal temperatures below 500F. Furnace coils are all welded construction with very short, direct lines to and from the reactors. There are no block valves from the furnace inlet to the depropanizer reboiler. To obtain a low pressure drop, the flow through each section of the furnace is divided into two passes. The recycle gas is pumped by reciprocating compressors driven by gas engines. The compressor ends, which have been trouble-free, are equipped with carbon pistons and carbon piston rings to eliminate lubrication. The absorber and depropanizer are perforated plate towers. Some difficulty has been experienced by accumulation of foreign materials lodging on the feed plates.

Table 1
Heath Catalytic Reformer

YIELD & OPERATING CONDITIONS Research Octane — clear	90		85		
Catalyst Age (days)	New	100	New	60	90
Charge	3090	3180	2980	3010	3030
Yield Wt. per cent					
Reformate	91.7	88.9	93.7	91.0	90.6
Dry Gas	8.3	11.1	6.3	9.0	9.4
REFORMATE					
Vol. Per cent Yield	89.0	87.0	91.5	89.8	89.7
Vol. Per cent Aromatics	54.4	49.9	49.1	49.0	48.9
HYDROGEN					
CF/B	574	504	813	629	482
Wt. Per cent	1.14	1.18	1.61	1.24	0.96
AVERAGE REACTOR TEMPERATURE F	895	935	886	909	914

A 15-day test run producing 90 to 98 plus 3 c.c. TEL octane reformate was completed in less than a month after startup. All guarantees as to throughputs, yields, and recoveries were met. In June, 1955, fouled exchangers dropped desulfurizer preheat below 500F. The exchanger surfaces were acid cleaned and perforated plates in both towers were cleaned by sandblasting. The reforming reactors were blocked in and not regenerated. Deposits found in the desulfurized naphtha and reformate condensers were practically 100 per cent ammonium chloride. Exchanger deposits were 80 per cent iron oxide, 14 per cent sulfur, with small amounts of chromium and compounds of ammonia and chlorine present.

In late July, 1955, a tube was lost in the "A" or preheating section of the furnace. A tube had been overheated by the combination of internal deposit and rather high heat density in the particular part of the furnace where failure occurred. During this shutdown, a light burn was taken on the reforming reactors to permit inspection of the tops of the beds.

In November, 1955, catalyst temperatures indicated loss of activity to a point where a shift of products might be expected, and the unit was shut down for acid cleaning and catalyst regeneration. After startup, "B" reactor pressure drop increased from a normal 4 psig to 22 psig and a hot spot developed on the shell, but the run was continued.

A full regeneration was taken in March, 1956. Relative activity and rapid aging tests indicated catalyst quality permitted increased aging. Furnace and exchangers were acid cleaned. Deposits of scale were found in "A" reactor to explain in part the unusual temperature pattern observed prior to shutdown. In "B" reactor, accumulation of scale on top of the bed caused the high pressure drop, and a split was found in the shroud protecting internal insulation to account for the hot spot. In "C" reactor, an inch or two of catalyst containing flakes of iron sulfide scale was skimmed from the top of the bed. Holes in the feed plates of the towers were increased from ⅛ in. to 3/16 in. and alternate rows of holes in all other plates were increased to the larger size.

This unit was designed to use an inert gas generator and a low-pressure gas compressor on a once-through basis for regenerating catalyst. The process heaters are fixed at a low rate to control the reactor inlet temperatures and oxygen content is controlled through inert gas production. Simultaneous burning in "A" and "C" reactors was introduced during the first regeneration cycle. Regeneration time was reduced by using the recycle gas compressors to circulate inert gas. Desulfurization catalyst is regenerated by burning with air and steam. ★ ★ ★

Water Purification At Toledo Refinery

Biological oxidation of waste material in used water solves a pressing disposal problem and furnishes 1500 gal per minute of usable water

Harry F. Elkin
Sun Oil Company

SUN Oil Company's new water re-use system at its Toledo, Ohio, refinery does a threefold job: Prevents pollution, conserves water, and provides ample water for fire protection.

The three needs are interrelated. Sun's new system deals with them simultaneously — and also eliminates extensive treatment procedures.

It has resulted in Toledo Refinery being able to satisfy 40 per cent of its water requirements from within. Or, to put it another way, the plant is re-using up to 1500 gpm from internal sources.

Sun's new system has been in the planning and design stage for five years and in operation for the past year and a half. Prior to this, with expanding operations at Toledo Refinery, now the largest in Ohio, company engineers were faced with the need for more water and for treating waste water.

Various alternatives were consid-

*Condensed from a paper given at the 21st Mid-Year Meeting of the API's Division of Refining in Montreal, May 16, 1956.

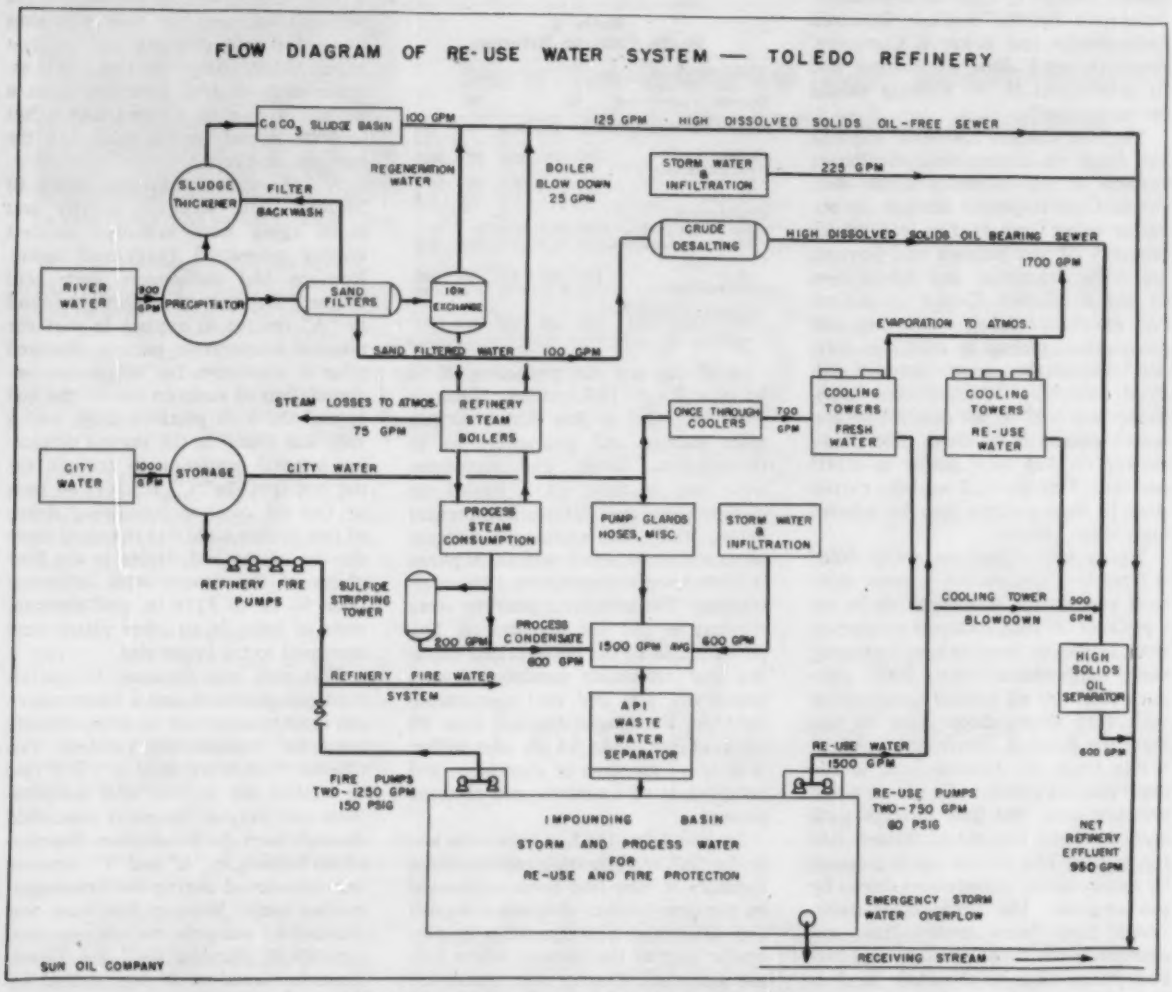
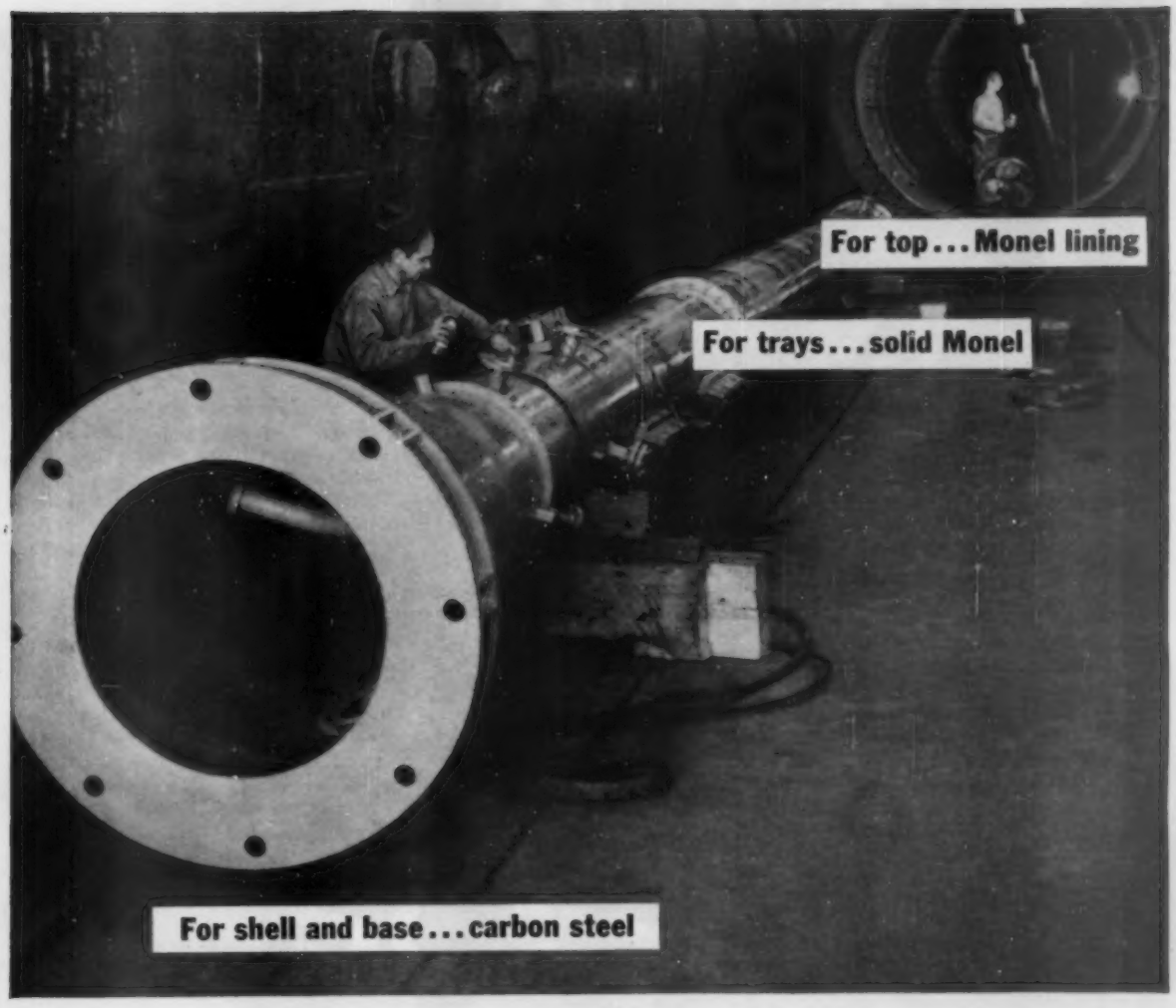


FIG. 1. Flow diagram of water reclamation system.



Monel combined with steel for economy in new fractionator

The complication in economical tower engineering is corrosion.

How much to accept? What corrosives are present? Where? How do temperature, pressure and stream velocity affect their action? Product clarity requirements? Materials capabilities? Fabricating precautions?

Often, definitive answers to questions like these prove unattainable without great expense. Fortunately, experience has shown a practical way to cut through the difficulty.

Take the tower shown. The company's engineers had experience with Monel* nickel-copper alloy . . . were familiar with its outstanding ability to resist tower-top corrosives . . . aqueous hydrochloric and sulfuric acids, and various salts.

With this in mind, they called on engineers from the fabricator, Fritz W. Glitsch & Son, Inc., for help in pinning down probable corrosion trouble spots. These men, in turn, worked with Inco's Corrosion Engineering Section.

Final "specs" put Monel alloy at each trouble spot, carbon steel elsewhere. Above the probable dew line (the top 15 feet, 6 inches), 3/32-inch Monel alloy lining was used. The eight trays (where agitation intensifies corrosion) were a special Glitsch design done in this same solid nickel-copper alloy.

It's good business to make tower engineering a *team* affair... bringing in the experience of your own engineers and consultants, the fabricator's and Inco's. You are better assured of economical construction and reliable tower operation.

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FIG. 2. Two 750 gpm each electric motor-driven pumps in the impounding basin pumphouse, with two diesel-driven spares in the background.

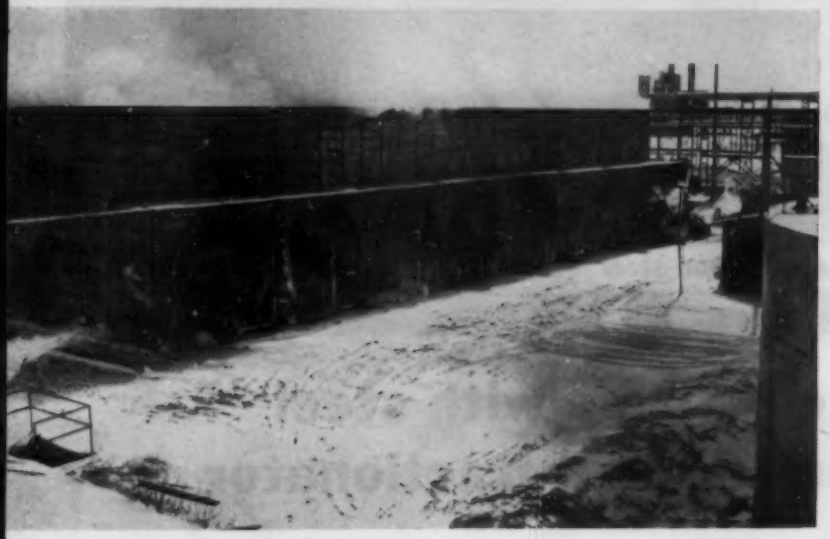

FIG. 3. Biological oxidation in this 18,000 gal/min cooling tower removes phenols, mercaptans, sulfides and other organic undesirables from waste water.

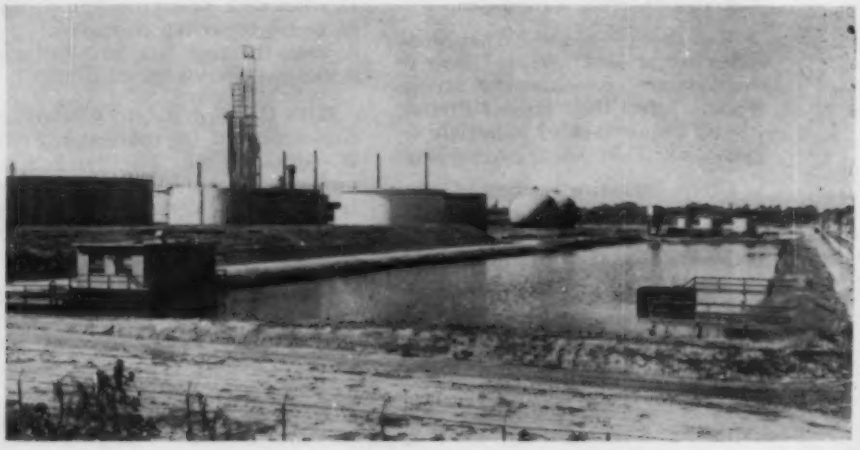

FIG. 4. Eight million gallon impounding basin can contain six days of process and runoff water; separators, slop storage tanks, and emergency fire pumphouse are shown.

ered, including installation of a supplemental river water pipe line with further raw-water treating equipment or the purchase of increased quantities of city water. After considerable study, it was decided to re-use existing plant waste waters rather than to increase the supply from outside.

First step in setting up the system was installation of a flue-gas stripping tower for removal of sulfides in process waters to be re-used.

Second was the segregating of low-alkalinity process waste waters together with storm water from ground runoff.

Also, an impounding basin 1200 ft long, 200 ft wide and 10 ft deep was built. From it the refinery has available some 600 gpm of storm water and infiltration of ground water, in addition to recovered plant waters.

Waste treatment is accomplished by selective segregation of waste waters at their source, removal of oil and settleable solids in conventional API separators, followed by a 4 to 6-day retention in the impounding basin and biological oxidation in cooling tower systems.

Cooling towers are used for this process for several reasons:

1. They have a relatively low quality water requirement.
2. They serve as a means for evaporating waste water.
3. They serve as ideal equipment for biological oxidation of organic materials in the waste water.

In this last respect, the cooling towers afford ideal water temperatures of 80 to 100 F; extensive internal contact surfaces in the form of wood packing; recirculation of waste water for repeated contact and dilution; and

When all the shouting is over and the last campaign speech has been made, isn't this what all the struggle is really about?

You and your neighbors are going to march to the polls November 6 and settle things the American way.

Not by fists or by force, not with a penalty if you don't vote, or the secret police checking up to see if you did.

You'll vote because it's the thing to do.

Vote as you please, of course—but vote.

Vote for the party and the candidates you honestly believe will represent you best.

But also vote because you believe in this democracy of ours and you want to keep it the way it is—a country where you can have your say and nobody else can say it for you.

Everybody you know will be there.

We'll see you at the polls.

VOTE NOVEMBER 6th!

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the presence of excess oxygen drawn into the tower by mechanical draft fans.

Nutrients for normal bacterial metabolism, such as nitrogen and phosphorous, occur in the cooling tower water in the form of ammonia from catalytic cracking process waters and in polyphosphate normally added to the cooling system for sequestering and corrosion inhibition.

The impounding basin, located at the outlet of the API separator, has a maximum liquid capacity of 8,000,000 gal. A minimum level of 1,500,000 gal of waste water is reserved for not less than 10 hours providing an emergency fire water supply.

This fire water supply is virtually inexhaustible since all water used in the plant can return to the impounding basin via the low solids contaminated storm and process sewer system.

Two 1250-gpm diesel-driven, vertical, centrifugal fire pumps are mounted at the basin. They provide emergency protection and augment the 3700-gpm fire pumping capacity already located within the refinery.

Oil-free waste waters, high in alkalinity and not suitable for re-use, including water plant ion exchange regeneration water and blowdown from steam boilers, are collected and sewered directly to the receiving stream.

Oil-bearing, high-alkalinity waste waters, including cooling tower blowdown and crude desalting wash water, are segregated in a new sewer system and delivered to a new auxiliary API high solids separator for oil removal before discharge.

The bulk of refinery waste waters is collected in the low-alkalinity re-use sewer and impounding basin system.

Two 750-gpm vertical, centrifugal water re-use pumps were installed at the impounding basin to return substantially all low-alkalinity process and storm water to existing refinery cooling towers as make-up with no pretreatment beyond gravity separation and impounding.

Phenol content in the re-use water has been reduced over 99 per cent during recirculation since the first day of operation, and chemical oxygen demand has been substantially lowered. There have been no adverse effects on heat transfer efficiency or on corrosion rates in the tubular cooling equipment.

The entire program represents a new approach to the multiple problems of refinery pollution abatement, water supply and fire protection. ★ ★ ★

To Collect LPG Statistics

Liquefied Petroleum Gas statistics will be collected, probably semi-monthly, by the American Petroleum Institute at the special request of the Natural Gasoline Association of America, according to definite plans. Eight geographical areas are involved.

Data will be collected and disseminated on propane, butane, propane-butane mixes, isobutanes and various other mixes. All companies now cooperating with the Bureau of Mines will be asked to continue this cooperation with the API.

Refineries Are 'Brightening Up'

Rainbow appearance in refineries is becoming common these days. The study recently completed by the E. I. duPont de Nemours Company has been spurring plants towards coloring to break the monotony of solid color painting. In addition to the anticipated favorable comments from the general citizenry, the color systems are expected to increase the efficiency of operations, decrease mental fatigue of operators, and improve employee morale. Increased safety may well result in many cases. Esso Standard has long been a proponent of scientific coloring systems, while Gulf and Leonard have recently announced the "rainbow" system for their refineries.

The growing use of platinum catalysts in reforming feed stock emphasizes the importance of pre-removing trace metals such as arsenic, lead and sulphur compounds. Platinum catalysts are poisoned by these substances in quantities even as small as ten parts per billion.

Treating the feed stock before the trouble occurs, Florex adsorbent provides the simplest, most economical means to protect expensive catalysts. Florex in the granular grades will completely remove or reduce these compounds to a harmless level.

Recognized throughout the world as superior to all other natural clays, Florex is prepared from carefully selected Florida Fuller's Earth by a special processing, including high pressure extrusion.

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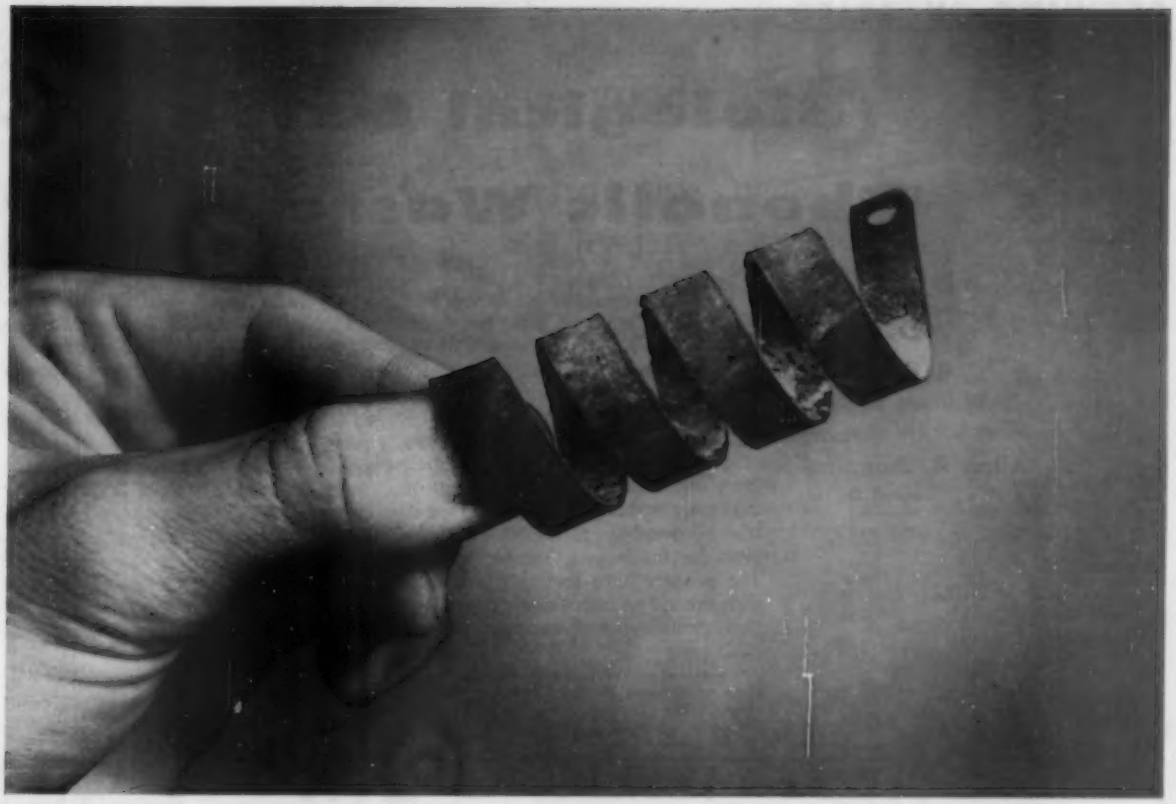

THIS STACK CONTROL element had to be removed from a domestic heating unit because of faulty operation caused by deposits. The non-metallic, ashless properties of Du Pont FOA-2 can help you reduce similar failures, and consequent service calls, to a minimum.

Many stack control failures can be prevented with this *ashless* additive

Du Pont Fuel Oil Additive No. 2 (FOA-2) can protect your distributors against many unprofitable service calls. Since it is a non-metallic, *ashless* additive, it burns completely, without leaving any significant trace of deposit to interfere with the operation of stack controls.

This ashless feature also means that heating oils stabilized with Du Pont FOA-2 will not contribute to deposits that cause shorting on the electrodes of the burner system. In this way, it helps to minimize ignition failures, too.

To prevent clogging of nozzles, screens and filters—another common cause of service calls costly to distributors—FOA-2 retards the formation of insoluble residues. And this stabilizing action is effective over unusually long storage periods.

FOA-2 also has an effective dispersant action which reduces the particle size of any residues that may form. And it helps to remove existing sludge deposits from the fuel system.

For best results, FOA-2 should be added to freshly prepared stocks at the refinery. It is economical to use because it is effective in low concentrations. Any of our sales offices listed below will be glad to supply you with the full details.

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REFINING IN BRIEF

Biological Oxidation Of Phenolic Waste Water

A. D. McRae, William K. Ross and Allan A. Sheppard
Imperial Oil, Ltd.

THE petroleum refineries in the Sarnia, Ontario, area are using biological oxidation as a practical means of removing phenolic material from waste water. A combination of phenol and chlorine in water treatment plants results in a "cocktail" that reminds one of a hospital corridor. It is essential, therefore, that the phenolic content of the receiving body of water be kept as low as possible, preferably below 5 parts per billion — a formidable task. The refiners have met this challenge with the aid of microscopic organisms that abound in soil and fresh water. The bacteria, which are of the non-pathogenic type, are conditioned to concentrations of phenolic material, consuming several hundred pounds per day.

The first step in reduction of phenolic material is good housekeeping. This entails a complete separation of contaminated water from other streams, elimination of leaks, and impounding of accidental spills. The process staff must be fully acquainted with the serious aspect of loss of phenolic material and an understanding of the biological process is necessary for good operation.

Biological oxidation of phenols can be carried out successfully if the ground

*Condensed by the authors from API Paper, given at Refining Meeting, Montreal, Canada, May 16, 1956.

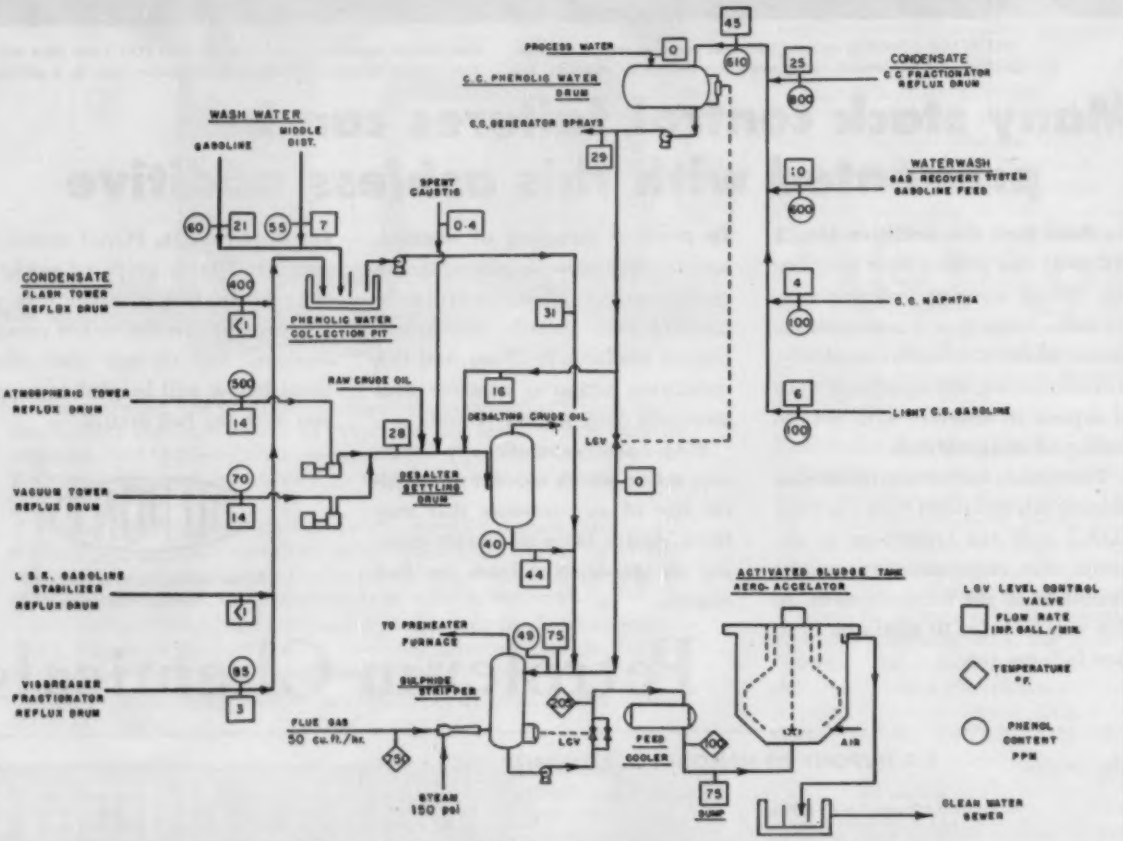

FIG. 1. Schematic diagram of phenolic water treatment system at Sarnia.

rules are obeyed. A uniform temperature of 80F to 100F, pH below 10, sufficient dissolved oxygen, and a low sulfide content are all requisites for maximum efficiency in operation. The bacteria must also have traces of nitrogen and phosphate which is supplied by small additions of ammonium phosphate.

Batches of bacteria were obtained from soil, manure heaps, and a chemical company in Michigan. These cultures were tested in the laboratories and eventually introduced in pilot units. After sufficient information was obtained, full-scale units were constructed and put into operation. The refineries have two years' experience in operating biological oxidation plants and are enthusiastic about the process which has proved to be more economical than chemical oxidation or incineration. There is proprietary equipment available for efficient oxidation and with uniform conditions of feed, no difficulty should be experienced. Careful training of plant supervisors is important and after the initial start-up the plants will operate with a minimum of attention, thanks to the efforts of the various technical staffs who solved the usual headaches connected with a new process. ★ ★ ★

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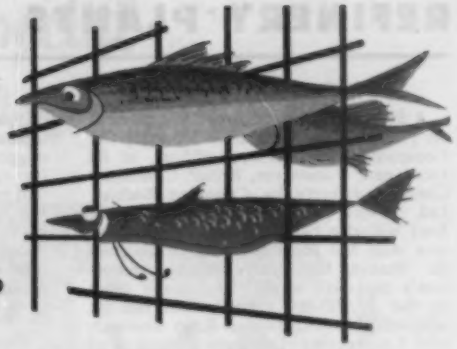
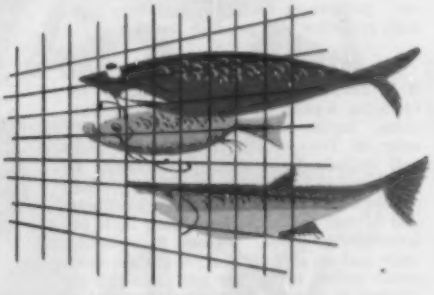
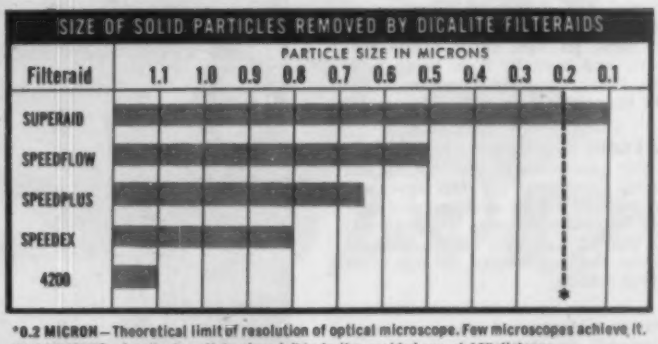


The major difficulty in securing trouble-free flood water is not the larger impurities, easy to precipitate or settle . . . it's the little devils which can slip right through when ordinary separation processes are used. These microscopic hellions . . . algae, bacteria (especially the sulfate-reducing bacteria) and chemical precipitants . . . find happy homes in the pores of the formation, grow there, increase and multiply till the formation is plugged and the water drive practically destroyed.

But they can't get through DICALITE!





*0.2 MICRON—Theoretical limit of resolution of optical microscope. Few microscopes achieve it.
80.0 MICRONS—Smallest particle size visible to the unaided eye at 10" distance.

That's why many of the diatomite filter systems now operating on water flood projects use Dicalite Filteraids. As the chart shows, there's a Dicalite grade to filter out unwanted particulates of any size—algae, bacteria, colloidal solids—even down in the submicron range. Simple tests made by Dicalite service engineers can quickly indicate the grade and amount required for any desired clarity at optimum flow-rate.

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REFINERY PLANTS SCHEDULED FOR COMPLETION

A 5000 B/D Powerformer will be built for Imperial Oil Company, a Standard Oil Company (New Jersey) affiliate, at its Ioco (near Vancouver, British Columbia, Canada) refinery by Canadian Bechtel, Ltd. A feed prefractionator and Hydrofiner will also be constructed in conjunction with the project, which is designed for "making the type of gasoline tomorrow's cars will need." The crude input to the 23,000-bbl refinery will not be affected. Powerforming is Esso Research and Engineering Company's version of fixed-bed reforming, utilizing a low platinum-content, long life catalyst.

Standard Oil Company of Texas will start construction of a 27,000 B/D Model IV Fluid Catalytic Cracker at its El Paso, Texas, refinery in December. Fluor Corporation, Ltd., was awarded the contract for design, engineering, and construction of the $5,000,000-plus unit. Included in the contract are complete "tail-end" processing facilities, including light ends recovery and product treating.

A new Japanese refinery. A 30,000 B/D refinery is being constructed for Idemitsu Kosan Company, Ltd. at Touyama, Japan, which is 800 miles southwest of Tokyo. The $25,000,000 plant will include four processes licensed by Universal Oil Products Company — fluid catalytic cracking, Platforming, Unifining, and Unisol treating. Also being built are atmospheric and vacuum distillation units and an asphalt unit. A carbon monoxide boiler, firing flue gas from the cat cracker is one of the unique features of the plant.

The refinery's products will include motor fuels, jet fuel, other prime fuel products, and asphalt. It is being built by The Japan Gasoline Company, Universal's licensing agent in Japan.

The 55,000 BPD fluid catalytic cracker previously announced by Humble Oil and Refining Company for its Baytown, Texas, refinery will be designed and constructed by Foster Wheeler. This unit will be the stacked type with the reactor vessel above the regenerator in the same structural setting.

Refinery underground storage to level out demands for butane is under construction for Pure Oil Company's Smiths Bluff refinery, Nederland, Texas. The 200,000-bbl cavity will be washed out from the Big Hill salt dome 25 miles southwest of the refinery. The salt formation is about 1700 ft below the surface. The cavity will be from 30 to 60 ft in diameter and extend about 2000 ft into the salt. Construction of a connecting pipe line will start in mid-October; the entire project is scheduled for a January 1 completion.

More synthetic rubber for Shell. New capacity for synthetic rubber to produce foam-type rubber goods is part of "several million dollars" building program by Shell Chemical Corporation at its Torrance, California, rubber plant. This is the only plant of its kind west of the Rockies. Capacity of the expanded plant will be 110,000 long tons, and it will be operating by early 1957.

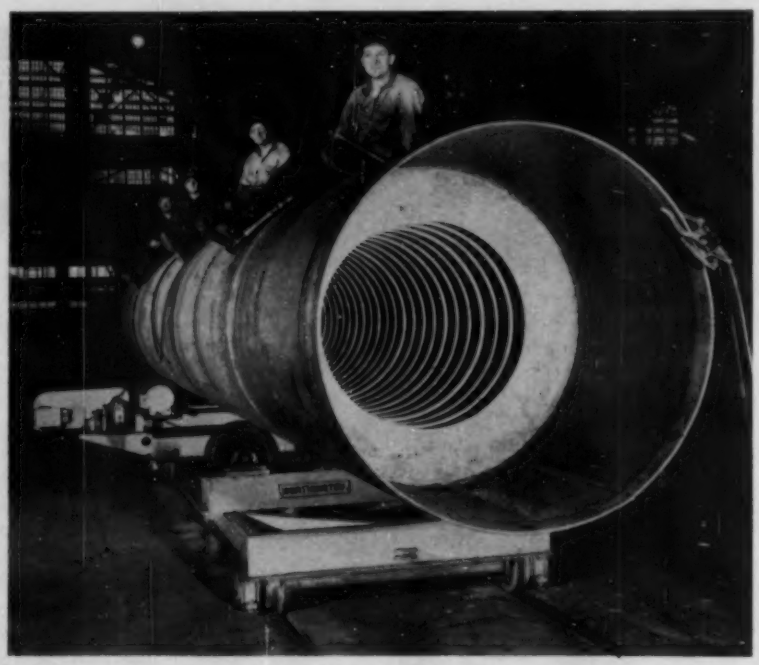
Ammonia plant for Venezuela. An air-separation plant to recover nitrogen and oxygen and a hydrogen purification plant for synthesis of ammonia in Venezuela, will be built during 1957 by Air Products, Inc., Allentown, Pennsylvania. The two plants will be the first such plants in South America, and the ammonia, 120 tons per day, will be employed to make explosives, fertilizers, and chemicals for domestic consumption.

Increased butadiene production is the objective of a multi-million dollar expenditure to be made at the world's largest butadiene plant. The Port Neches, Texas, installation, purchased by Texas-U. S. Chemical Company and Goodrich-Gulf Chemical, Inc., from the government in 1953, will be expanded by 50 per cent to 300,000 short tons annually. Work has already begun, and some of the increased production will be realized in late 1957, the balance scheduled for fall of 1958. The plant is operated by Neches Butane Products Company.

Joining atomic research efforts is the DuPont Company. A $2,000,000 radiation physics laboratory will be built at DuPont's Wilmington, Delaware, experimental station. High-energy, atomic-type particles will be generated by electrical equipment housed in the facility. Fundamental research is the present objective, the lab to supply information to various departments of the company for translation to commercial processes.

21,000,000 gallons a year of aromatics is the planned production for a new plant and auxiliary equipment to be built by Frontier Oil Refining Company at its 30,000 BPD Buffalo, New York, refinery. Feed stock for the unit will be supplied by a 7500 BPD catalytic reformer now under construction. Design and engineering is almost complete and construction will start promptly, with completion expected during the latter part of 1957. Frontier, a division of Ashland Oil and Refining Company, will market most of the production of benzene, toluene, xylene, and other aromatics through the R. J. Brown Company of St. Louis, Missouri, another (and recent) affiliate of Ashland. It is expected that the production will be absorbed by local and Northeastern U. S. consumers.

A 7000 BPD refinery will be constructed for El Paso Natural Gas Products Company by Southwestern Engineering Company of Los Angeles, California. The $8,000,000 to $10,000,000 plant, which will be a few miles of Gallup, New Mexico, will have provisions for expansion to 13,000 BPD. A complete fuel products plant, its facilities will include fluid catalytic cracking, H. F. alkylation, and Platforming. The refinery is the first major installation of its type in northwestern New Mexico and is scheduled for completion in October, 1957. Products will be marketed in its home state, and adjacent parts of Arizona, Colorado, and Utah.



The largest ever built, this 60-in. rotary-disk contactor for an oil refining process will be over 60 ft tall. Inside the vessel will whirl shaft-mounted disks that match the concentric rings welded to the shell. The rotor will operate at 65 to 200 rpm and must be statically and dynamically balanced. The contactor, of all-welded construction, is being built by Baldwin-Lima-Hamilton Corporation for Tidewater Oil Company's new Delaware Flying A Refinery near Wilmington.

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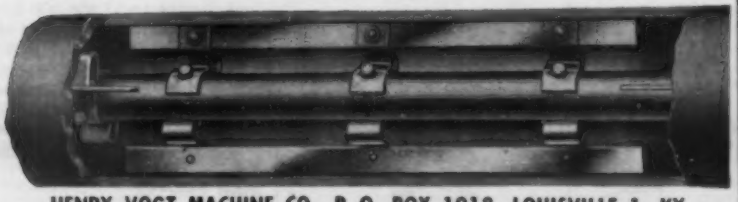

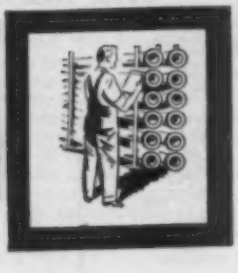

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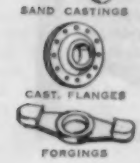

PR-23

Additional research facilities, to be built over a two-year period at Whiting, Indiana, have been announced by Standard of Indiana. Dr. Robert E. Wilson, Standard Oil board chairman, said that the probable cost would be $8,000,000. While part of the construction is for replacement of outmoded buildings, a great deal is being devoted to additional space for pilot units of major size. The new 58,000-sq ft pilot plant building will be able to house units up to 60 ft high and will have office space and labs for about 115 people.

Effect of atomic radiation on petroleum products and intermediate stocks will be studied in a $500,000 laboratory to be constructed by Continental Oil Company at Ponca City, Oklahoma. Radiation source will be from fuel elements in two-foot-long uranium cylinders, which will be shipped from the AEC's plant at Arco, Utah.

Odessa Butadiene Company will construct a 50,000-ton per year Houdry butane dehydrogenation unit at a site near Odessa, Texas. Fluor Corporation, Ltd., is in charge of construction, with completion scheduled for July, 1957.

Brazil will increase refining capacity from 5000 to 37,000 BPD with a major expansion by Petroleo Brasiliero at its Mataripe, Bahia, facility. Products will include gasoline, LPG, lube oils, and waxes. The lube plant will be Brazil's first, and will have a capacity of 3000 BPD. It is planned to run Brazilian crudes at the expanded refinery.

A 25,000 BPD residuum stripper will be built by The Fluor Corporation at Standard of California's El Segundo, California, refinery. The stripper will provide feed for a Model IV catalytic cracker, and provide heavy residuum for fuel oil. Completion is slated for April, 1957.

A catalytic reformer will be added to Salt Lake Refining Company's refinery. The company, a Utah Standard of California subsidiary, is now inviting bids for the 6000 BPD unit.

Salt Lake Pipe Line Company, another Socal holding, is starting construction of additional storage facilities along its line to the Idaho-Washington region to handle a greater volume from the Salt Lake refinery.

British American Oil Company is adding two crude distillation units to its 21,500 BPD Clarkson, Ontario, Canada, refinery. The units will have a combined capacity of 40,000 BPD. Canadian Kellogg, Ltd., has been awarded the construction contracts.

The Fluor Corporation of Canada, Ltd., has been awarded a contract to engineer and construct a $3,800,000 detergent alkylate plant for Imperial Oil, Ltd., at Sarnia, Ontario, Canada, a 1957 completion.

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REFINING AND PETROCHEMICAL PERSONALS

George H. Meason, formerly with the technical and research department of the Humble Oil & Refining Company in Baytown, Texas, has joined the Tennessee Gas Transmission Company as chief process engineer.

G. H. Meason

He will develop a technical organization within the company's plants and processing department. Meason and his staff also will be available in connection with processing and technical problems of the Bay Petroleum Corporation, a wholly-owned subsidiary of Tennessee Gas.

Karl W. Shimeall, vice-president refining, Crown Central Petroleum Corporation, has been elected vice president of the corporation in charge of southwestern operations.

Richard T. Colquette, vice president of Pan-Am Southern Corporation, has taken early retirement from that corporation and will succeed Shimeall as vice president-refining.

Dr. Charles L. Fleming, Jr. has been elected a vice president and director, Esso Research and Engineering Company.

He will serve as board contact for research on chemicals, pipe line, lubricating oil processes and crude oil production.

Harold J. Rose was appointed coordinator of chemicals research.

Dr. John G. McNab was promoted to deputy coordinator for petroleum products and medical research.

Dr. Miller W. Swaney, director of the Enjay Laboratories, was named Dr. McNab's successor. **Elfried F. H. Pennekamp** succeeded Dr. Swaney.

Guy B. Hunter, president of Quaker State Oil Refining Corporation, Oil City, Pennsylvania, was re-elected president of the National Petroleum Association at the 54th annual meeting in Atlantic City, New Jersey, in September.

Other officers re-elected at a board of trustees meeting were: First vice president —**Paul R. Beck,** Pennsylvania Refining Corporation, Butler, Pennsylvania; and second vice president—**Rexford S. Blazer,** Ashland Oil & Refining Company, Ashland, Kentucky.

George E. Freyermuth has been elected to the chairmanship of the board of Standard Oil International, Ltd., and of Esso Export, Ltd., both Standard Oil Company (New Jersey) subsidiaries. He will be headquartered in London.

Joining the Louisiana division of Esso as a chemical engineer in 1928, Freyermuth became manager of public relations for the company in New York, then was made executive vice president of Esso Export Corporation in 1954.

Philip Freneau has been appointed to the newly created position of chief project engineer of the manufacturing division of Southwestern Engineering Company of Los Angeles, California.

French joins Sweco after a 10-year affiliation with the Elliott Company, Jeannette, Pennsylvania, where he most recently served as chief engineer of the company's general apparatus division.

Dr. Bruno H. Wojcik has been named manager of research and development for industrial chemicals division of Olin Mathieson Chemical Corporation. He will be located in Baltimore, Maryland.

Wojcik came to Olin Mathieson in 1950 from the Hooker Electrochemical Company, Niagara Falls, New York. He is known for his work in the polymerization and high pressure hydrogenation fields.

Bernard H. Nicolaisen has been appointed assistant manager of research and development in charge of the division's laboratories at Niagara Falls, and **Dr. Chester White** will supervise the Rochester, New York, laboratories.

Dr. B. H. Wojcik

R. C. Sweeney

M. E. Peterson

Dr. L. E. Orth

Robert C. Sweeney has been appointed manager of market development of Sinclair Chemicals, Inc. He will be in charge of the company's market research and product development activities with headquarters in New York. **Dr. Leo E. Orth** has been named agronomist in Sinclair's nitrogen products division headquartered in Chicago. He will handle the marketing of anhydrous ammonia and nitrogen solutions. He formerly was director of research and agronomist with Minnesota Farm Bureau Service Company in St. Paul.

Also announced was the appointment of **Maurice E. Peterson** as sales representative, nitrogen products division. Peterson will handle sales of Sinclair's anhydrous ammonia and nitrogen solutions. He will make his headquarters in Blencoe, Iowa.

Managers for five new operating divisions created by the reorganization of Sinclair Refining Company's manufacturing department are: **R. E. Howe,** processing division, will advise on improving operations of existing equipment and approve all process design in future projects; **J. E. Bell,** engineering and maintenance division, will direct engineering for existing refinery equipment and approve engineering on future projects; **G. F. Kuhn,** refinery production division, will handle crude and project evaluations, cost studies, and study of long range projects dealing with overall department economics; **K. A. Beach,** asphalt and chemicals divisions, will direct the supply of asphalt products to the sales department and chemicals to the chemical department and **A. D. Hill,** lube oil production division, will be responsible for all lube oil and wax matters, approve all lubricating and grease formulations, and direct barrel house and laboratory operations.

Lester Ginsburg, vice president of Electric Bond and Share Company, has been elected to the board of directors of Escambia Bay Chemical Corporation.

Ernest Danner and **Olin M. Herner** have been promoted to the positions of electrical engineer and chemical engineer, respectively, of Commercial Solvents Corporation.

Herner joined the company in 1941 and has served in a series of increasingly important positions, with the most recent being that of department head in CSC's Terre Haute riboflavin plant. Danner started with Commercial Solvents in 1940. He was electrical maintenance foreman at the Terre Haute plant for 14 years prior to assuming his present duties.

John Rysdorp, assistant treasurer and assistant comptroller of Shell Chemical Corporation, has been presented with a diamond studded pin for his 35 years of service with Shell Oil and Chemical Companies.

Richard T. Ozimek has been named supervisor of petrochemicals market research for Commercial Solvents Corporation.

Formerly, he held the position of market analyst with the National Aniline Division of Allied Chemical and Dye Company.

Ozimek will be responsible for coordination of all market research for the company's petrochemical products, making his headquarters in New York City.

Elzie Wolker and **Quentin R. Jeffries** have been elected to the staff of Commercial Solvents Corporation, engineering activities. Both men will make their headquarters at the company's Terre Haute, Indiana, research and production center.

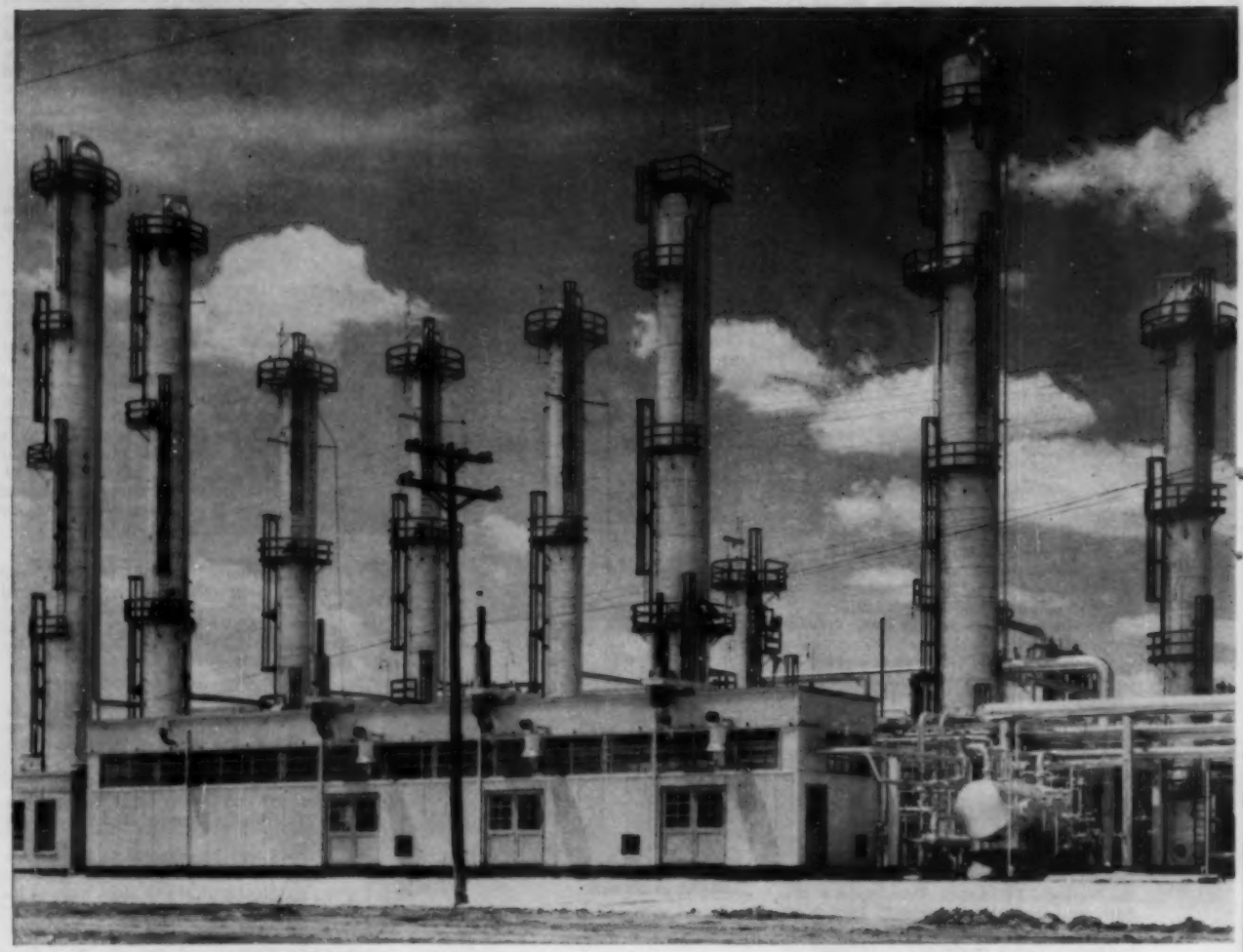
Dr. Bernard L. Evering has been appointed a senior research associate in the Standard Oil Company (Indiana) research department at Whiting, Indiana. He has been with Standard since 1934.

In his new position he will head a staff of organic research authorities in developing improved gasolines to meet requirements 10 years from now.

Earlier in his career with the company, Dr. Evering did much of the pioneering work on isomerization of paraffins that led to the Isomate process for making aviation gasoline.

PROCON BUILDS UOP REXFORMING UNIT FOR COSDEN IN RECORD TIME

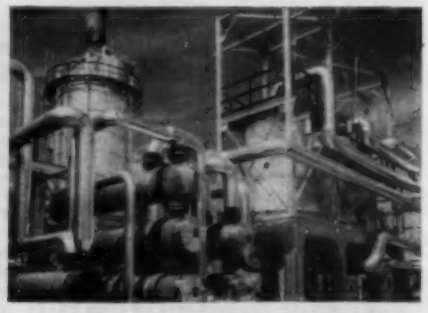
Another important oil refinery construction achievement for Procon



New Rexforming unit at Cosden just after going on stream

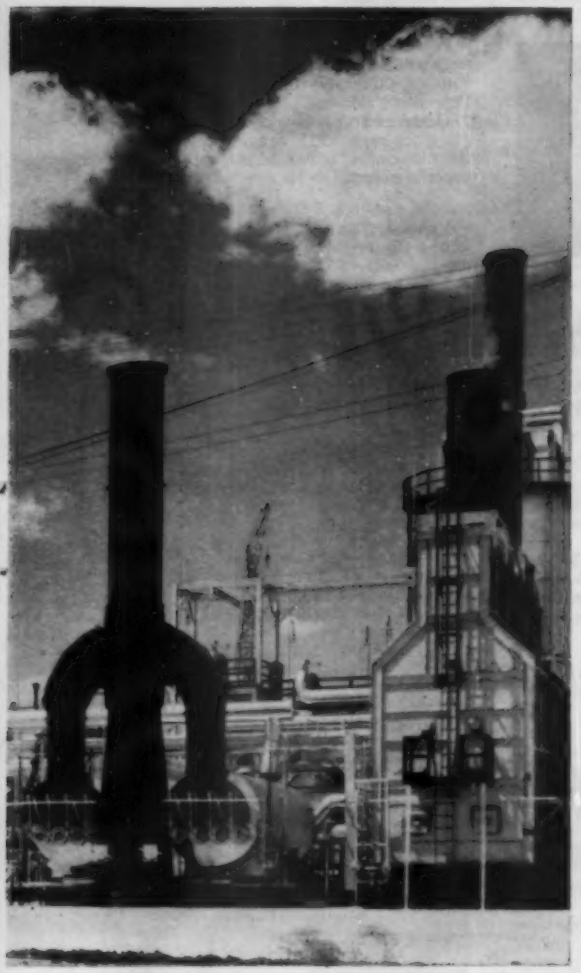
Ray Tollett, President (center) and Dan Krausse, Manager of Production (left) of Cosden congratulate Martin McReynolds, Field Construction Superintendent for Procon

This control room directs the operation of the Rexforming unit



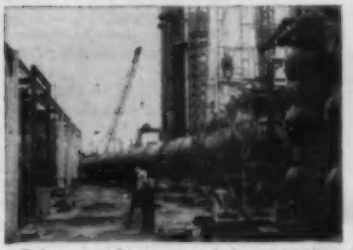
The heart of the Rexforming unit, the Reactors

Some months ago, Cosden Petroleum Corporation, Big Spring, Texas, gave Procon the responsibility of building their new Rexforming refining unit. Cosden's requirements for the construction specified completion "at the earliest possible time". Procon finished this project, the first Rexforming unit anywhere in the world to be built wholly from the ground up, in approximately six months. It is an outstanding example of Procon's ability to meet the most exacting construction requirements on time and right up to every specification.



Site 30 days after ground breaking

Ground was broken for the new Rexforming unit on January 18, 1956 and completion was promised in approximately six months. In order to meet this time requirement, Procon engineers realized it was necessary to break away from routine methods and use every time-saving method possible consistent with good construction practice. Accordingly, it was decided to proceed as far as possible with the basic construction even before the major columns could be finished and placed in position. This presented a delicate problem since, as the columns were completed and delivered, it was necessary to move them into position with the rest of the construction being ahead of the usual status for their easy installation. This was handled without flaw by the Procon construction crew on the job and the new unit went on stream just 190 days after ground had been broken.



Column just fits in space between partly completed construction

Column is carefully maneuvered into place

One of the principal problems was the positioning of the extractor column, RXV10, the largest in the unit. It had to be fitted carefully into the half-completed construction and maneuvering it into position in a space that permitted only a few inches leeway was an unusually competent construction accomplishment.

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100 Fellsway, Somerville 45, Mass.
Offices in Major Cities
Jerguson Trees Gage & Valve Co., Ltd., London, Eng.
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Personals

B. R. Dorsey has been appointed coordinator in the Gulf Oil Corporation's manufacturing department. Formerly he was supervisor, scheduling and cost control, manufacturing department. He will be located in the general offices of the company, Pittsburgh, Pennsylvania.

John E. Ford, Jr. has been elected chairman of the board and chief executive officer of the U. S. Oil & Refining Company, Tacoma, Washington. One of the original founders of the company, he has been acting as petroleum advisor to the company for the past 18 months.

J. E. Ford Jr.

J. E. McKay

John E. McKay has been appointed to the business development staff of Ralph M. Parsons Company, Los Angeles.

He was formerly associated with The Fluor Corporation, Ltd., for 14 years in various sales capacities.

William W. Wilson has been named manager of terminals for the petrochemicals division of Commercial Solvents Corporation.

A member of the Commercial Solvents organization since 1936, Wilson has held a series of increasingly important positions in the company's research, engineering and production programs. Prior to joining CSC, he was engaged in water survey activities with the state of Illinois as a staff chemist.

John W. Towler has been appointed to the newly-created position of director of manufacturing for Union Oil Company. **W. T. Jameson,** assistant manager at the Los Angeles, California, refinery, will become manager. Towler formerly was manager of Union's Los Angeles refinery.

V. H. Goodwin and **P. L. Lafosse** have been named supervising engineers, and **H. L. Post** senior design engineer in engineering division at Humble Oil & Refining Company's Baytown, Texas, refinery.

Goodwin will be in charge of the group that provides engineering guidance and inspection service for the lube extraction and light oil treating units. Lafosse will supervise the group engaged in design work on various refinery equipment. Post will handle problems in connection with the operation and maintenance of refinery power plants and electrical substations.

Elmer R. Erickson has been elected president of Northwestern Refining Company, of St. Paul Park, Minnesota.

He formerly was executive vice president and secretary of the company. Erickson, who has been with the company since its founding 17 years ago, also is a director.

The appointment of eight men to supervisory posts at Tidewater Oil Company, Wilmington, Delaware, has been announced.

The new supervisors, and the posts they will hold are: **Elwood C. Bailey,** supervisor of the crude area; **Robert C. Carter,** supervisor of the cracking area; **Roger W. Edwards,** supervisor of the alkylation and polymerization area; **Gordon G. Gaddis,** supervisor of the reforming area; **Paul W. Jepsen,** supervisor of oil dispatching; **John J. Mack,** chief engineer; **John Searl,** supervisor of the utilities and sulfur recovery area, and **Clarence E. Slater,** supervisor of the coking area.

Francis G. Hester has been named maintenance and engineering superintendent of Great Northern Oil Company's Pine Bend refinery.

Hester, who has been with Great Northern since early 1955, previously served as chief engineer and assistant maintenance superintendent.

Yoonsik Lee of Teague, Korea, has joined the research department of Commercial Solvents Corporation at the company's Terre Haute, Indiana, Research Center. He has been assigned to research engineering and pilot plant studies.

Prior to coming to the United States, Lee was associated with the United Rubber Company of Chongju, Korea, in a technical capacity.

R. P. Hooper has been appointed manager of British American Oil products supply department. with headquarters in Toronto, Canada. Hooper joined British American in 1949.

Joseph R. McHugh has been named superintendent of the Newark, New Jersey, plant of Commercial Solvents Corporation.

McHugh has been associated with CSC in various plant capacities since 1949, most recently as office manager. Also announced was the appointment of **Herbert C. Hermann** as office manager of the plant.

Hermann joined CSC in 1947 as assistant office manager of the former plant at Carlstadt, New Jersey.

J. A. Anderson Jr.

E. W. Bowerman

J. A. Anderson, Jr., has been promoted to research associate, and **E. W. Bowerman** to assistant division head in research and development division at Humble Oil & Refining Company's Baytown, Texas, refinery.

Anderson holds the BS degree in chemical engineering from University of Illinois and the MS degree from Pennsylvania State University. Bowerman received the BS degree in chemical engineering at South Dakota State School of Mines, and the PhD in chemistry at Ohio State University.

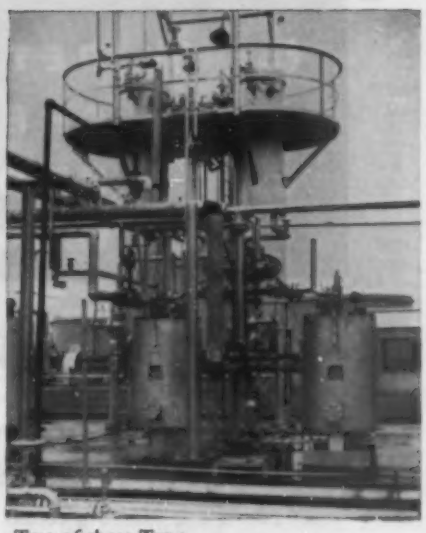
Standard Oil of Ohio added two 30,000 cu. ft. underground caverns for storing propane

Lectrodryers DRY that gas as it comes out of storage*

Standard Oil of Ohio's propane customers are assured of gas that is safely DRY. No moisture to cause contamination or valve freeze-ups. The propane is dried to a low dewpoint as it is taken out of storage.

Lectrodryers are available for DRYing air, gases and organic liquids at pressures ranging from atmospheric to 6,000 psi. They'll handle a few cubic feet per hour for simple laboratory tests, a few hundred feet for instrument air, for example, or hundreds of thousands of feet on routine refinery production.

Lectrodryer engineers will help you decide where you need a drier, select and furnish a Lectrodryer and auxiliary equipment to meet your requirements. For DRYing help and for literature on the control of unwanted moisture, write Pittsburgh Lectrodryer Company, 334 32nd Street, Pittsburgh 30, Pennsylvania (a McGraw Electric Company Division).



Two of these Type BWC-500 Lectrodryers handle the DRYing of Standard Oil of Ohio's propane.

Previously, propane was only stored here above ground in these tanks.

In England: Birlec, Limited, Tyburn Road, Erdington, Birmingham.
In France: Stein et Roubaix, 24 Rue Erlanger, Paris XVI.
In Belgium: S.A. Belge Stein et Roubaix, 320 Rue du Moulin, Bressoux-Liege.

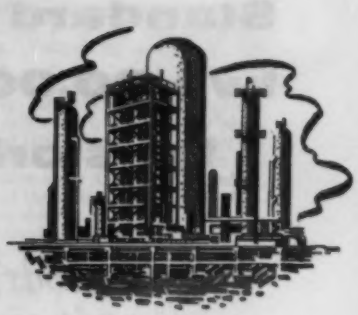
LECTRODRYERS DRY WITH ACTIVATED ALUMINAS

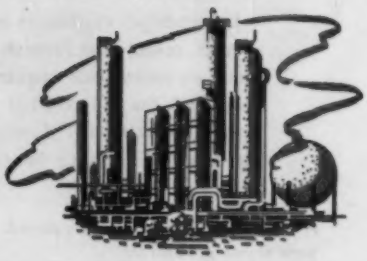
LECTRODRYER

* REGISTERED TRADEMARK U.S. PAT. OFF.

HEAT EXCHANGERS

for the PETROLEUM, CHEMICAL and PROCESS Industries



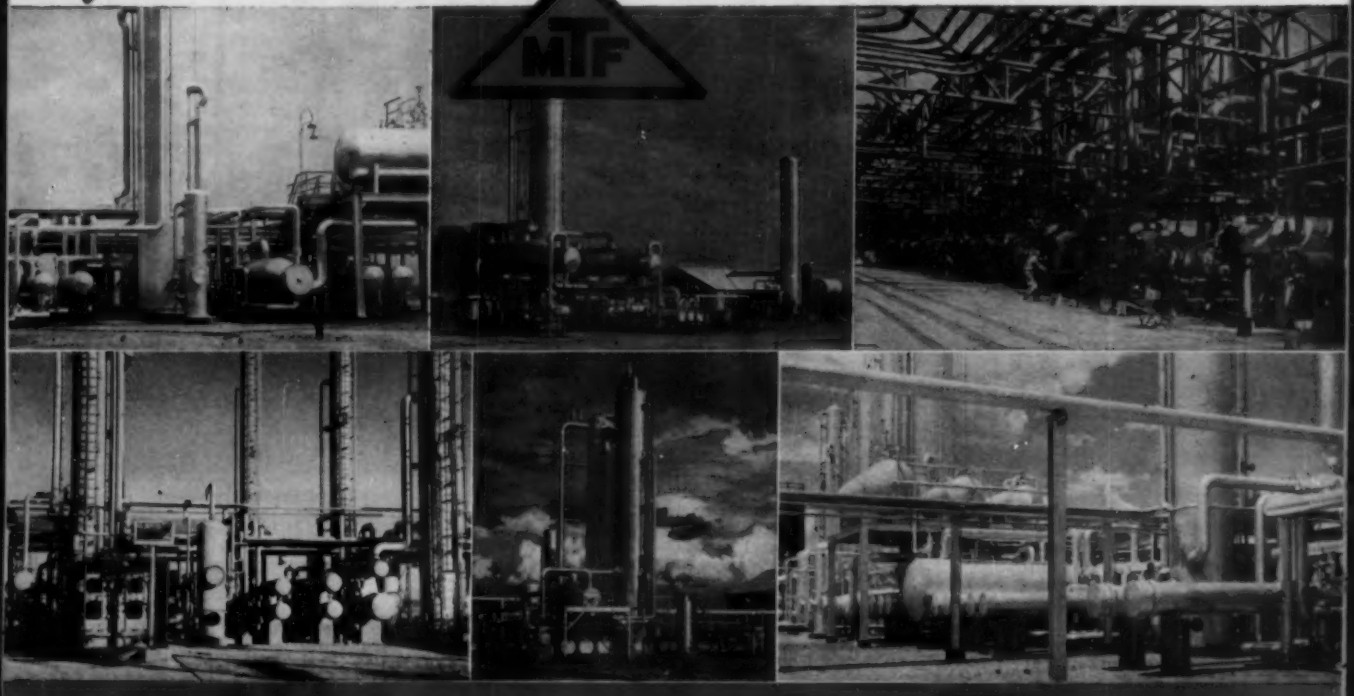


Texas Metal is engaged exclusively in the design, fabrication and repair of shell and tube heat exchangers. We are specialists in the field of custom designed heat transfer equipment for specific requirements.

We would welcome the opportunity of quoting on your Exchanger requirements and extend a cordial invitation for Engineering Counsel on any heat transfer problems you may have. No obligation, of course.

Texas METAL FABRICATING CO.

MAIL ADDRESS: P. O. BOX 7567, HOUSTON 7, TEXAS



API-ASME and ASME Code Construction

▸ Four new sales representatives, Commercial Solvents Corporation, automotive specialties and anti-freeze sales, have been engaged.

J. P. Weary and **D. W. Dever** join the company's Kansas City, Missouri, offices. **N. D. Torchio** and **Edward Randolph** have been assigned to the company's general offices in New York City.

▸ **Norman J. Linstromberg** has been named district manager of the Dayton, Ohio, office of Ethyl Corporation, succeeding **Robert R. Mead,** who is on special assignment at the company's central region headquarters in Chicago, Illinois.

Prior to his present promotion, Linstromberg was a sales representative in Kentucky.

▸ **Willis F. Sims** has joined Catalytic Construction Company as refinery sales representative for the Southwest area, with headquarters located in Tulsa, Oklahoma.

He was formerly refinery manager at Wichita Falls, Texas, for Panhandle Oil Corporation.

▸ **Professor Warren Kendall Lewis...** Massachusetts Institute of Technology, will be first speaker in the University of Texas annual Schoch lecture series. He will describe recent advances in fluidization October 16 and 17 in three lectures open to the public.

Lewis, who has taught at M.I.T. since 1910, is coauthor of the first chemical engineering textbook, and is an outstanding consultant on fluidization and distillation problems in the petroleum refining and petro-chemical industries.

▸ **Clarence E. Means** has been named operations superintendent for the jointly owned Roberts Ranch gasoline plant in Midland County, Texas, operated by Cities Service Oil Company.

Frank Snyder of Cities Service Hutchinson, Kansas, LP-Gas storage terminal, succeeds Means as superintendent of the company's Burrton, Kansas, gasoline plant. **John Paxton** was moved from Cities Service's Chico, Texas, gasoline plant to Hutchinson as assistant superintendent. **Wayne Flinz,** Bartlesville, Oklahoma, gasoline division office, transferred to the Chico plant as operations superintendent.

J. M. Brown

E. N. Kimes

▸ **E. N. Kimes,** refinery manager, has retired and **John M. Brown** has been appointed his successor at the El Dorado, Arkansas, refinery of Pan-Am Southern Corporation. Brown was formerly assistant manager.

H. K. Wheeler, formerly assistant manager-technical, will become assistant refinery manager. **J. D. Walk,** formerly of the manufacturing department staff of American Oil Company, will become superintendent-technical.

▸ **John D. Mohler,** manager, asphalt department, Pan-Am Southern Corporation, has resigned, and **Charles Taylor,** special representative, has been named acting manager.

Taylor joined Pan-Am in June, 1951, as special salesman, asphalt.

▸ **R. T. (Russ) Watson,** for 36 years a member of British American Oil's manufacturing department and most recently manager of the company's Edmonton refinery, retired from active service in September. At a dinner in his honor, he was presented with a gold watch.

Watson joined B-A at Toronto refinery in 1920.

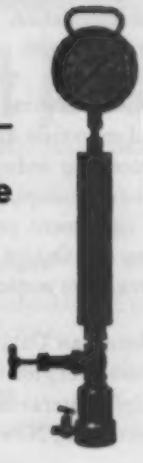
▸ Shell Oil Company has announced six staff changes in head offices, New York, and at the Martinez, California, refinery. They are: **F. C. Cutting,** assistant to the vice president, economic development, will become assistant to the vice president, personnel and industrial relations; **J. E. Marsland,** manager of the head office manufacturing technological department, will become assistant to the executive vice president; **J. M. Brackenbury,** superintendent at the Martinez refinery, head office manufacturing technological department; **J. B. Dunlap,** assistant superintendent at the Martinez refinery, as superintendent; **J. B. St. Clair,** assistant manager, head office manufacturing technological department, as assistant superintendent at Martinez, and **H. E. Walker,** chief research technologist at the Houston, Texas, manufacturing research laboratory, as assistant manager, head office manufacturing technological.

REID VAPOR-PRESSURE BOMBS

For Either Pressure or Immersion Sampling

for testing Natural Gasoline – Benzol Blends – and other liquids not exceeding a vapor pressure of 45 lbs. at 100° F. by the Reid Method.

Construction conforms strictly to A.S.T.M. specifications. Requires no wrench—By means of the "O" ring gasket hand coupling will make a tight seal. Each bomb tested for 200 pounds air pressure.



Over 20,000 items—Scientific instruments and laboratory supplies.

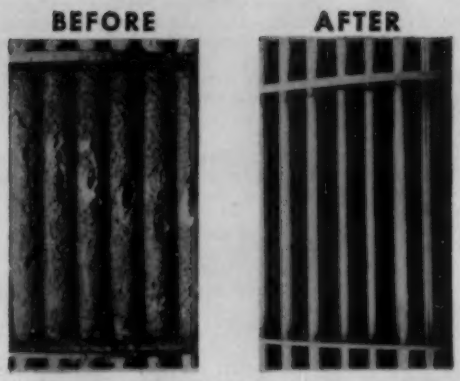
cenco

The most complete line of scientific instruments and laboratory supplies in the world.

REFINERY SUPPLY COMPANY

621 EAST FOURTH STREET ● TULSA 3, OKLAHOMA
2215 McKINNEY AVENUE ● HOUSTON 3, TEXAS

CENTRAL SCIENTIFIC COMPANY
1700 IRVING PARK ROAD ● CHICAGO 13, ILLINOIS
CHICAGO NEWARK BOSTON WASHINGTON DETROIT SAN FRANCISCO
SANTA CLARA LOS ANGELES TORONTO MONTREAL VANCOUVER OTTAWA



Heat Exchanger bundle before and after cleaning with recommended solvent and improved Oakite Compound 88

Keep Exchangers at Peak Capacity with fast Oakite cleaning

Look at the Heat Exchanger bundle, left above—the one that looks ready for the scrap heap. Can't be much heat transfer taking place with all that build-up of deposit.

Now look at the picture on the right. Same bundle? Yes, the same bundle—...cleaned by Oakite chemical circulation method. Restored to peak performance with minimum out-of-service time.

Similar cleaning short-cuts with Oakite methods and materials are possible throughout the whole processing industry. Cat crackers, fractionating towers, pumps, compressors, drums—each piece of equipment presents a separate cleaning problem, and Oakite has worked out the best *chemical circulation method for cleaning "in place"*.

There's an Oakite man near you whose service is yours, free, for the asking. Call him. Or write for helpful literature to Oakite Products, Inc., 59 Rector St., New York 6, N. Y.

OAKITE

Export Division Cable Address: Oakite

Technical Service Representatives in Principal Cities of U. S. and Canada

Atomic Energy Used in Gasoline Manufacture

Scientists of The Atlantic Refining Company have announced their discovery of a new method for synthesizing gasoline by the use of atomic energy.

In a paper presented to the American Chemical Society at its 130th national meeting, in Atlantic City, New Jersey, Dr. V. J. Keenan and his colleagues from Atlantic's Philadelphia, Pennsylvania, research laboratories described the bombardment of butane hydrocarbons that yielded octane, a major component of gasoline.

The starting material butane is a gaseous hydrocarbon often found in suburbanites' "bottled gas." Atlantic scientists liquify this gas by cooling and circulating it through a reaction vessel exposed to the beam of an electron accelerator. This machine emits a stream of electrons traveling at terrific velocities, which enter the butane reaction vessel and initiate the chemical changes leading to gasoline components.

In contrast to the conventional methods of "cracking" butane and the subsequent polymerization steps to produce gasoline, this new radio-chemical route produces a minimum of undesirable by-products and may thus simplify the refining steps now employed. The Atlantic researchers have indicated that their studies are continuing to determine the commercial feasibility of using atomic energy in manufacturing gasoline.

IN-BUILT SIMPLICITY...

GUARANTEES

LONG, TROUBLE-FREE SERVICE

Here's the simplest and most efficient pump valve made for reciprocating pumps. The ROYAL CROWN PUMP VALVE has only three separate parts, yet its performance is revolutionary! Valve is guided by a frictionless ball stem which allows it to oscillate and turn with the fluid stream. Swings completely free with each stroke of the pump... seating each time in a new position. Resistance to fluid is reduced to a minimum which means greater pump volume at less pump speed. Adaptable to all reciprocating pumps... handles all types of liquids.

Royal Crown PUMP VALVES

(A) Round valve surface is streamlined. No obstructions to restrict the flow. (B) Ball-guided valve rotates and swings with each stroke of the pump. Each turn, each swing... a lapping action, a continuing perfect seat. (C) Free vertical action assures instant opening and closing. Ball stem is a frictionless guide.

MADSEN WORKS

CONSTRUCTION EQUIPMENT DIVISION
Baldwin-Lima-Hamilton Corporation

WRITE FOR DESCRIPTIVE LITERATURE

14120 EAST ROSECRANS AVE., P. O. BOX 38, LA MIRADA, CALIFORNIA

MATCHLESS STEAM HOSE

"U. S. Matchless #5 does 5 different jobs,"

says refinery division superintendent

"It always passes our strictest lab tests."

A mechanical division superintendent of a leading Midwestern refinery says:

"U.S. Matchless Steam Hose always passes our central maintenance department tests, and we've always had good experience with it. The neoprene cover is oil-resistant. The hose is highly flexible and light in weight. Asbestos ply, under the cover, conserves heat. Wire braid preserves static ground."

This great "U.S." hose is serving many industries in many ways. It is obtainable at selected "U.S." distributors, at any of the 28 "U.S." District Sales Offices, or write us at Rockefeller Center, New York 20, N. Y.

Uses in refinery for U.S. Matchless® #5 Hose:

- As a firefighting hose, for safety-checking atop the 235-ft. cracking unit (see picture above).
- In propane tank, to thaw bottom of gauge glass in cold weather (see inset picture above).
- In pump room of cracking unit, as a steaming line to get gas traces out of the unit.
- On propane transfer line, to prevent orifice from freezing in cold weather.
- Enables construction crews to run temporary steam lines more cheaply and quickly than using pipe.

Mechanical Goods Division

United States Rubber

UNIVERSAL CONVERSION FACTORS

INCH OF WATER @ 60° F (Continued) =

0.0000254	kilograms per square millimeter
559,946	pounds per square hektometer
5,599.463120	pounds per square dekameter
55.994631	pounds per square meter
5.202004	pounds per square foot
0.0361250	pounds per square inch
0.559946	pounds per square decimeter
0.00559946	pounds per saaure centimeter
0.0000559946	pounds per square millimeter
2,540,000	hektograms per square hektometer
25,400	hektograms per square dekameter
254	hektograms per square meter
23.596005	hektograms per square foot
0.163862	hektograms per square inch
2.54	hektograms per square decimeter
0.0254	hektograms per square centimeter
0.000254	hektograms per square millimeter
25,400,000	dekagrams per square hektometer
254,000	dekagrams per square dekameter
2,540	dekagrams per square meter
235.960045	dekagrams per square foot
1.638617	dekagrams per square inch
25.40	dekagrams per square decimeter
0.2540	dekagrams per square centimeter
0.002540	dekagrams per square millimeter
8,959,141	ounces per square hektometer
89,591.41	ounces per square dekameter
895.9141	ounces per square meter
83.232058	ounces per square foot
0.5780	ounces per square inch
8.959141	ounces per square decimeter
0.0895914	ounces per square centimeter
0.000895914	ounces per square millimeter
254,000,000	grams per square hektometer
2,540,000	grams per square dekameter
25,400	grams per square meter
2,359.600439	grams per square foot
16.386192	grams per square inch
254	grams per square decimeter
2.54	grams per square centimeter
0.0254	grams per square millimeter
2,540,000,000	decigrams per square hektometer
25,400,000	decigrams per square dekameter
254,000	decigrams per square meter
23,596.004	decigrams per square foot
163.861920	decigrams per square inch
2,540	decigrams per square decimeter
25.40	decigrams per square centimeter
0.2540	decigrams per square millimeter
25,400,000,000	centigrams per square hektometer
254,000,000	centigrams per square dekameter
2,540,000	centigrams per square meter
235,960	centigrams per square foot
1,638.619198	centigrams per square inch
25,400	centigrams per square decimeter
254	centigrams per square centimeter
2.54	centigrams per square millimeter
254,000,000,000	milligrams per square hektometer
2,540,000,000	milligrams per square dekameter
25,400,000	milligrams per square meter
2,359,600	milligrams per square foot
16,386.192	milligrams per square inch
254,000	milligrams per square decimeter
2,540	milligrams per square centimeter
25.40	milligrams per square millimeter
0.00245562	bars
0.00245818	atmospheres
248,885,374,188	dynes per square hektometer
2,488,853,742	dynes per square dekameter
24,888,537	dynes per square meter
2,313,937	dynes per square foot
16,096.0079	dynes per square inch
248,885	dynes per square decimeter
2,488.853742	dynes per square centimeter
24.888537	dynes per square millimeter
68.44	feet of water @ 62° F and 29.92 Barom. Press.

JOULE (ABSOLUTE) =

23.730	foot poundals
284.760	inch poundals
0.73756	foot pounds
8.85072	inch pounds
0.000000263331	ton (net) calories
0.00023889	kilogram calories (mean)
0.00526661	pound calories
0.00842658	ounce calories
0.23889	gram calories (mean)
238.89	milligram calories
0.000000115740	kilowatt days
0.0000002778	kilowatt hours
0.0000166667	kilowatt minutes
0.001	kilowatt seconds
0.0000115740	watt days
0.0002778	watt hours
0.0166667	watt minutes
1	watt seconds
0.000112366	ton (net) meters
0.101937	kilogram meters
0.224733	pound meters
3.595721	ounce meters
101.937	gram meters
101,937	milligram meters
0.000368654	ton (net) feet
0.334438	kilogram feet
0.737311	pound feet
11.796960	ounce feet
334.438274	gram feet
334,438.273531	milligram feet
0.00442385	ton (net) inches
4.013259	kilogram inches
8.847732	pound inches
141.563520	ounce inches
4,013.259288	gram inches
4,013,259	milligram inches
0.0112366	ton (net) centimeters
10.1937	kilogram centimeters
22.4733	pound centimeters
359.5721	ounce centimeters
10,193.7	gram centimeters
10,193,700	milligram centimeters
0.112366	ton (net) millimeters
101.937	kilogram millimeters
224.733	pound millimeters
3,595.721	ounce millimeters
101,937	gram millimeters

Compiled by Steven Gerolde, Gulf Oil Corporation.

CUT ALONG THIS LINE FOR YOUR PERSONAL REFERENCE FILE.

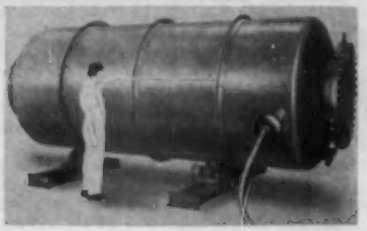
NEW Refining Equipment

• machinery • supplies • services

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

(41) Purifier Conserves Water and Steam. Plants can conserve water and steam through the use of Model LS Hi-eF Purifier.

Instead of exhausting spent steam to the atmosphere, purifier is installed in low-



pressure steam lines to remove oil, scale, and other impurities so that the condensate can be returned to the boiler.

The new LS Hi-eF Purifiers are made in a wide range of sizes, easily installed like a valve or other fitting in a pipe line.

V. D. Anderson Company.

(42) Submerged Pump. A new line of submerged pumps is now being manufactured by Granberg.

Pumps are designed to eliminate priming problems completely, regardless of temperature of liquid. This Granco submerged pump is available in a complete, ready-to-install, package unit with discharge column and driving head integral with the pump.

Granberg Corporation.

(43) Shutoff and Alarm for Heating Processes. A safety shutoff and alarm for automatically controlled processes, said to be the first which requires no sensing elements or electronic circuitry, has been introduced by Damol.

Damol Impulse Monitor provides a complete, safe shutdown of the process and sounds an alarm in the event of controller failure in the "on" period, and an alarm in the event of abnormal "off" period or fusing of the power contactor.

Damol Corporation.

(44) "Packaged" Lubricating Oil System Center. Processes employing compressors and steam turbine drives can benefit from a "packaged" lubricating oil system center developed by Allis-Chalmers.

Shipped completely assembled, the units are mounted on a common base. A compact arrangement for oil reservoir, pumps, motor, turbine, coolers, and filters permits increased accessibility to gages and maintenance points.

Allis-Chalmers Manufacturing Company.

(45) Ultrasonic Thickness Measurement. An ultrasonic thickness-measuring instrument, the SO-100 Sonizon, has been announced by Magnaflux.

Unit is portable, weighing only 30 lb. at least 20 lighter than previous resonance-type equipment. Its small case, light weight, and long (five-foot) search cable make it adapted for use in constricted areas.

Magnaflux Corporation.

(46) Discharge-Type Vacuum Gage. A single-station, discharge-type vacuum gage which gives continuous pressure readings over an extended range from 25 microns to 1×10^{-7} mm Hg is now available from the Rochester Division of Consolidated Electrodynamics.

Designated the PHG-27, this instrument measures the total pressure of condensable vapors and permanent gases on three scales: 25 microns to 1×10^{-4} mm Hg; 1×10^{-4} to 1×10^{-5} mm Hg; and 1×10^{-6} to 1×10^{-7} mm Hg.

Rochester Division.

(47) Industrial Teflon Hose. Availability of what is claimed to be the first Teflon hose with detachable, reusable fittings has been announced by Aeroquip. Hose is proposed for applications where unusual exposure to wide temperature ranges and injurious chemical action is encountered.

Aeroquip Corporation.

(48) Power Tool Grinds Valves in Line. One man is now said to be able to regrind any globe or gate valve from ¼ in. to 12 in. without removing the valve from the line.

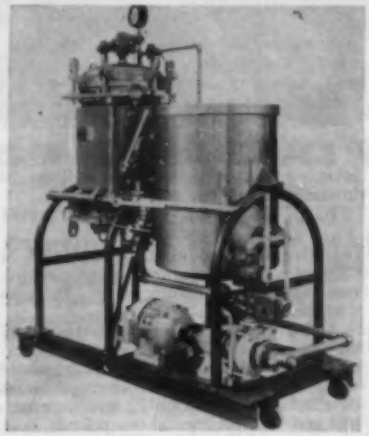
Through the use of a new high-speed motor and recently developed abrasive-cloth grinding elements, the new machine can grind the seat of any valve regardless of material hardness, the manufacturer says.

The Motor-Driven Dexter Valve Reseating Grinder is available in compact kit form in three basic models for globe or gate valves.

Leavitt Machine Company.

(49) Portable Filtration Station. Duriron has introduced a stainless steel Durco-Emzinger filtration station as a portable package unit. The station is designed for pilot plant or other small batch operations.

Complete unit consists of a vertical-leaf pressure filter with 21.2 sq ft of leaf area,



a precoat and slurry tank, pump, valves, and complete piping, all mounted on a portable frame.

The Duriron Company.

(50) Loading Assembly. Oil Equipment Manufacturing has introduced tank truck loading assembly No. 901.

Loader is equipped with compression-type spring, serving as a counter balance

enclosed in a tight cylinder and adjustable spring buffer which brings the loader to a smooth stop when returning to upright position.

Unit includes a shockless, self-closing loading line valve and telescopic sleeve, presently available in 2, 2½, and 3-in. sizes. Dual poppet and cam construction permit ease of opening and shockless closing.

Oil Equipment Manufacturing Company, Inc.

(51) Pipe Markers. Engineers now can standardize the pipe identification system for their entire plant with the new Brady Self-Sticking Perma-Code Pipe Markers.

With pipe identification standardized, tracing pipe lines is said to be quick and sure. Pipe markers come in stock heights to fit any size pipe and are made of all-temperature vinyl-cloth and silicone-plastic overcoated for long life. Letters on ASA Standard A-13 Background Colors identify pipe contents with both color and legend.

W. H. Brady Company.

(52) Corrosion-Proof Flooring. Ceilcote has announced the development and manufacture of Corocrete "A," a corrosion-proof floor material which provides increased protection from attack by alkalis, solvents, and acids.

Developed for application directly over concrete, the new material is composed of three basic ingredients: (1) a thermosetting resin liquid, (2) a hardening agent and (3) an aggregate-type filler. This material is mixed at the job site for immediate application.

The Ceilcote Company, Inc.

(53) Portable Moisture Determinator. A portable moisture determinator for use in field stations, laboratories, or quality control points, is announced by Central Scientific.

This apparatus, called the Cenco Karl Fischer Moisture Determinator, is completely self-contained, weighs only 22 lb. and can analyze liquid, solid, and gaseous samples. Utilizing the Karl Fischer method of water content determination, the instrument can be operated any place where 115-v, 60-cycle current is available.

Central Scientific Company.

NEW Literature

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

(54) Properties of Infrared Transmitting Materials. A Servo brochure provides comparative information on 15 different infrared transmitting materials suitable for use as optical elements. Transmission curves are included for the 11 most important materials.

Servo Corporation of America.

(55) Expansion Joints. A 72-page illustrated catalog published by Zallea Brothers, covers the design, manufacture, and application of the company's line of packless corrugated expansion joints, including three new types.

Catalog introduces Zallea's new self-equalizing, duo-equalizing and high-pressure toroidal expansion joints.

Zallea Brothers.

(56) Infrared Spectroscopy to Data Processing. A Beckman buleltin features articles on infrared spectroscopy and data processing.

Featured are infrared articles on the IR-4 double-beam, double-monochromator infrared spectrophotometer plus unusual applications for the Beckman L/B Infrared Analyzers.

The Beckman "111" data system with its "pinboard control" is also described.

Beckman Instruments, Inc.

(57) Lauric Acid. Aceto Chemical has issued a bulletin on Lauric Acid.

This product, which finds use in the manufacture of Lauric Ethanolamide-type foam stabilizers and Lauric Acid Esters is manufactured by N. V. Koninklijke Stearine Kaarsenfabrieken "Gouda-Apollo" of Holland, which Aceto represents in the U. S. A.

Aceto Chemical Company, Inc.

(58) Jet-Tray Deaerator. A Cochrane publication describes a deaerator design that eliminates tubular vent condensers without impairing efficient purging of non-condensible gases.

This type deaerator handles the widest range of operating conditions and is said to provide maximum effective scrubbing contact between steam and water, thus assuring highly efficient oxygen removal.

Cochrane Corporation.

(59) Fluorocarbon Products. The forms, properties, and uses of a wide range of fluorocarbon products — from plastic resins to acids and dielectric fluids — are described in an eight-page brochure published by M. W. Kellogg.

Detailed in the booklet are the types and grades available of each form of KEL-F fluorocarbon products and their suggested uses.

The M. W. Kellogg Company.

(60) Insulation Problems. A four-page, two-color brochure describing Gilsulate insulation for hot underground pipes has been published by American Gilsonite. The illustrated brochure discusses the problems of underground pipe insulation and explains how Gilsulate's special properties overcome them.

American Gilsonite Company.

(61) Alloy Steel Tubing. Technical information on 12 of the most widely used "4100 series" of alloy steels is presented in a four-page folder issued by Babcock & Wilcox.

Included in the folder are condensed data on carburizing and thermal treatments, critical points, mechanical properties, and suggestions on welding and machining of these steels.

The Babcock & Wilcox Company.

(62) Corrosion-Resistant Process Equipment. The latest edition of the Pfaudler Buyer's Guide to the chemical industry covering the firm's corrosion-resistant process equipment has been released.

This buyer's guide lists project engineering facilities for designing a complete new operation or for revamping an existing process. It also gives information on custom-built process equipment, glassed steel reactors, alloy reactors, columns, heat exchangers and condensers, evaporation equipment, storage, mixing and trailer tanks, as well as standard accessories for all of these pieces of equipment.

The Pfaudler Company.

(63) Liquid-Level. A newly revised eight-page three-color catalog covers Jerguson's latest designs in remote-reading, liquid-level gages, including the Red Flasher Truscale. The Red Flasher Truscale has a scale which flashes continuously in red for a positive warning when boiler water level gets too high or too low. Illustrated catalog covers remote reading gages in four pressure groups from under 900 psi to over 1500 psi.

Jerguson Gage & Valve Company.

(64) Diaphragm Valves and Metering and Proportioning Pumps. A 16-page, two-color catalog featuring Hills-McCanna Diaphragm Valves and Metering and Proportioning Pumps has been released by Hills-McCanna.

Also featured is the Hills-McCanna-meter—the precision pump for precision metering.

Hills-McCanna Company.

(65) Meters and Controls. Over 100 measuring, transmitting, receiving, recording, and indicating instruments and control components for power and process applications are described in an eight-page bulletin issued by Bailey Meter.

Bulletin includes detailed literature reference for each product as well as 24 instrument and control applications.

Bailey Meter Company.

(66) Organic Products. A catalog of "Sharples" brand synthetic organic chemicals has been announced by Pennsalt Chemicals.

Listed in the 12-page brochure are 77 commercially available products with formulas, product descriptions, and suggested uses. In addition, the brochure contains detailed information on 22 semi-commercial and 17 experimental compounds, samples of which are available in limited quantities from laboratory and pilot plant production.

Pennsalt Chemicals, Pennsylvania Salt Manufacturing Company.

(67) Power Plant Control Equipment. A 12-page booklet that describes power plant control equipment is now being made available by the Copes-Vulcan Division of Blaw-Knox.

Reviewed in detail in the brochure are combustion and boiler-feed water control, pressure reducing, desuperheating, and automatic soot blowing, the latter including retractable and rotary soot blowers.

Copes-Vulcan Division, Blaw-Knox Company.

(68) Process Control. A new concept in process control brings to process instrumentation systems the latest systems design techniques developed in the servo mechanism field.

New brochure indicates facilities of Feedback Controls to improve the effectiveness of existing control systems.

Feedback Controls solicits contracts from processors contemplating new construction for design of complete plant control systems to be engineered simultaneously with process equipment design, resulting in improved and cost-conscious control. The performances of the systems are predicted quantitatively before installation.

Feedback Controls, Inc.

(69) Cold Water Deaerator. Cochrane has a publication out which describes the many advantages of cold water deaerators and their principles of operation.

Some of the advantages claimed for the Cochrane Cold Water Deaerator are: (1) Reduces or eliminates corrosion; (2) complete deaeration without heating or cooling; (3) tremendous spilling edge for maximum deaerating efficiency; (4) multiple-stage units permit economical deaeration.

Cochrane Corporation.

(70) Entrainment Separator. Schuyler has issued a four-page bulletin describing and illustrating how "Schuylernit" Entrainment Separators (mist eliminators) operate, as well as various applications for separators, types of construction, installations and laboratory-proven results.

Schuyler Manufacturing Corporation.

(71) Chemical Resistant Coatings. A four-page, illustrated bulletin now available from Metal & Thermit describes three general classes of chemical-resisting organic coatings that have been developed to meet the needs of processing industries.

These three classes are: (1) Ucilon coating systems applied like paint for general corrosion control; (2) Unichrome plastisol compounds for heavy-duty service, and (3) Unichrome special materials for lining steel drums and tanks.

Metal & Thermit Corporation.

(72) Chemical Feeders and Mixers. Infilco has released two bulletins on chemical feeders and mixers.

One is a two-color, illustrated "Neusol" feeder bulletin on chemical feeding equipment for use in the treatment of waters and wastes. The "Neusol" Feeder is a compact solution feeder which incorporates either one or two positive displacement diaphragm pumps.

"Chemical Mixers and Feeders" is the title of the other bulletin, an eight-page brochure, with numerous illustrations and diaphragms. Paddles revolving in a vertical plane within the tank are said to prevent stratification of the lime mixture.

Infilco, Inc.

the Pipeline Engineer

Oil..Gas Products Pipelining

You Can't Patch It - If You Can't Find It!

These Electrical Detectors Show Up Weak Spots in Protective Coatings

E-4 Portable, pack-type, all-purpose, holiday detector with wet-cell battery output adjustable from 2500 to 20,000 volts D.C. Inspection electrodes for pipe sizes 2 to 30-in. diam. also steel brush for surface checking. E-4 checks dry surfaces only.

E-P Holiday detector similar to E-4 but suitable for testing either wet or dry surfaces. The best general-purpose holiday detector made. Comes in sturdy carrying case with battery charger.

H-2 Pipeline "Jeep" which will rapidly field test the coating on any transmission pipeline. Needs no trailing ground wire. Maintains a constant electrical potential on the pipeline at all times. Signals coked or burned spots in coatings as well as holes. This unit has seen service in all parts of the world.

M-1 Belt-mounted inspection instrument weighing but 3 lbs. Wand holds cellulose sponge which is dampened with plain water. When wiped over any painted or coated surface up to 10 mils thick it will signal pinholes or breaks by bell signal.

BEAT NATURE TO THE PUNCH

Your protective coatings on metal or concrete are only as good as their weakest points. Nature will seek out pin-holes and thin spots caused by air bubbles, dirt, coke or rust in the protective coating. Be safe and check pipe or other painted surfaces before putting them into severe service. A Tinker & Rasor electrical detector can quickly find the weak spot in your coating—wet or dry. It can do so rapidly and efficiently and without physical damage to the coating in any way. There is a T & R Holiday Detector for every surface testing job + each is fully guaranteed.

Write for data, costs, specifications. Inquiries receive prompt attention.

TINKER & RASOR

203 E. Del Mar Pl. • Phone: ATlantic 7-7942
SAN GABRIEL, CALIFORNIA

DISTRIBUTORS: Bonco Mfg. Co., Inc., Tulsa, Oklahoma; Crutcher-Rolfs Cummings, Houston, Texas; Line Products, Elizabeth, New Jersey; Canadian Equipment Sales & Service, Edmonton, Alberta

THE MODERN VIEWPOINT ON SCRAPER TRAPS

SELF-SEALING GASKET — made of Hycar (oil and gas resistant rubber) — is the final answer to scraper trap leaks. Its lipped design makes it self-sealing under line pressure. The coupling cannot be over-tightened to the extent of damaging the gasket or the coupling itself.

UNIBOLT

No threads to gall or freeze . . . No leaky seals . . . No doubt about strength — it conforms to all codes . . . No multi-bolt flanges.

Release two bolts. Swing the trap open. Take the pig out or put the pig in. Close the trap and tighten two bolts. That's just how simple and easy it is to operate a UNIBOLT Scraper Trap. An over-size barrel (slightly larger than the o. d. of the pig) makes it equally easy to start a pig. Line pressure does the heavy work.

Pipeliners everywhere are using UNIBOLT closures and couplings for scraper traps, blowdowns, strainers, mist removers and other large diameter pressure vessels.

THORNHILL CRAVER CO.
P. O. BOX 1184 HOUSTON, TEXAS

SPRINGFIELD GAS LIGHT CO.

STABILIZES BY REMOTE CONTROL

...with Foxboro TELETAX* Telemetering

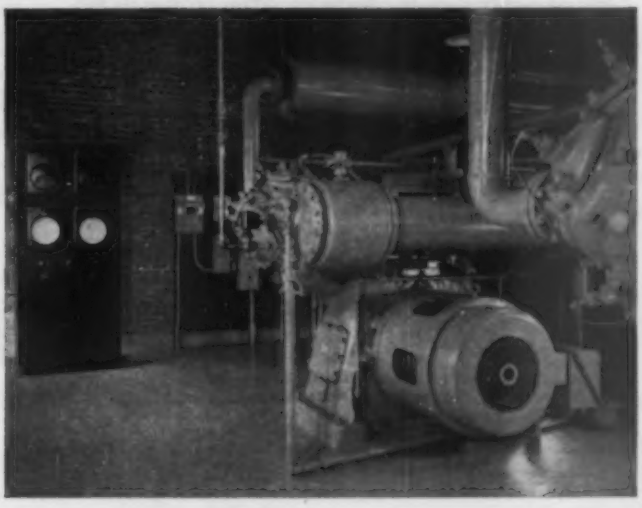
Here's another modern utility that's assuring highest efficiency in a key operation through Foxboro Teletax Telemetering. Using this advanced supervisory control system, the superintendent at Springfield Gas Light Company's main plant has complete command of gas stabilizing operations at the city gate, three miles away. A B.T.U. Recorder continuously shows him the heating value of the gas; a Teletax Receiver indicates the air/gas ratio being maintained. If gas varies from pre-set B.T.U. value, he pushes a button either to raise or lower air-to-gas ratio and restore proper B.T.U. value.

This is only one of many Teletax installations, specifically engineered to meet a wide variety of requirements. Assure your operation highest efficiency and economy with Teletax . . . for transmission of *any* standard Foxboro Measurement over *any* transmission system. Write for Bulletin 17-11A. **The Foxboro Company, 3810 Norfolk Street, Foxboro, Mass., U.S.A.**

FACTORIES IN THE UNITED STATES, CANADA, AND ENGLAND.

FOXBORO
Reg. U.S. Pat. Off.
TELETAX TELEMETERING

*Reg. U. S. Pat. Off.



Using Teletax Telemetering, the supervisor at Springfield Gas Light Co.'s main plant (above) controls desired, air/gas ratio at compressor station (below) three miles distant. The company purchases gas from the Tennessee Gas Transmission Company line, stabilizes it to maintain a constant B.T.U. value.

Typical installation of American Hammered Conformable Oil Rings

Insures constant unit pressure for positive oil control!

You keep your oil consumption down when you install Koppers American Hammered Conformable Oil Rings! This service-tested piston ring conforms readily to meet cylinder distortion because its flexible cast iron member is pressed outward by an abutment type spring which exerts uniform radial pressure around the entire circumference.

Narrow bearing surfaces on either side of the channel give the ring a uniform unit pressure on the cylinder, enabling it to seat promptly and assuring maximum removal of excess oil throughout its lifetime. And the Conformable Oil Ring has a longer useful life because its low spring rate and uniform lands result in negligible changes in pressure as the ring wears.

Easily installed, it is ideal for both 2-cycle and 4-cycle Diesel & Gas engines; comes in 4″ to 25″ diameters with a minimum width of ¼″. Write, wire or phone us today for full information on how the Conformable Oil Ring can improve *your* operation . . . or for expert help in *any* piston or sealing ring problem. KOPPERS COMPANY, INC., *Piston Ring Dept.*, 1710 Hamburg Street, Baltimore 3, Maryland.

KOPPERS

METAL PRODUCTS DIVISION • KOPPERS COMPANY, INC. • Baltimore, Maryland

This Koppers Division also supplies industry with Fast's Couplings, Aeromaster Fans, Koppers-Elex Electrostatic Precipitators and Gas Apparatus.

Engineered Products Sold with Service

AMERICAN HAMMERED
Industrial Piston Rings

KOPPERS COMPANY, INC., *Piston Ring Dept.*, 1710 Hamburg Street, Baltimore 3, Md.

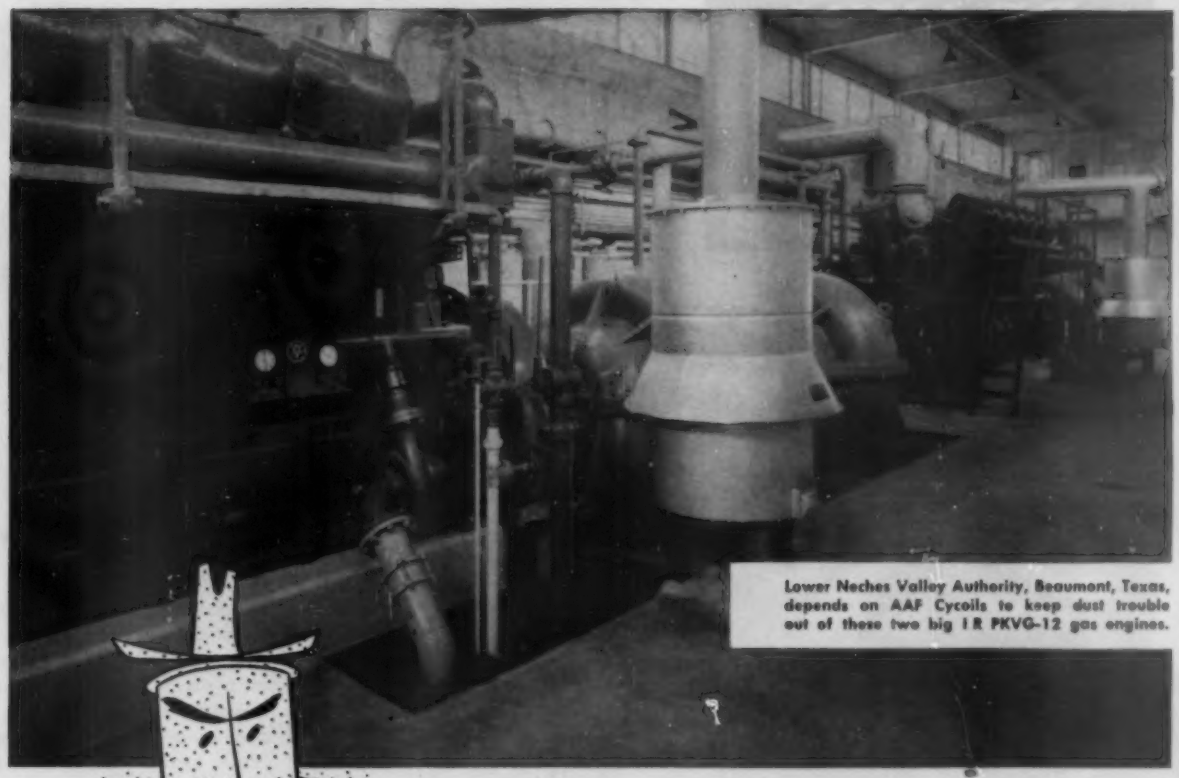
Gentlemen: Please send me full information on your Conformable Oil Ring.

Name.....

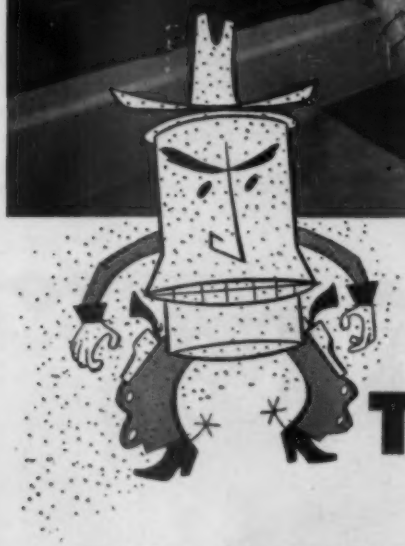
Company.....

Address.....

City.....Zone.....State.....



Lower Neches Valley Authority, Beaumont, Texas, depends on AAF Cycoils to keep dust trouble out of these two big I R PKVG-12 gas engines.



CYCOILS Corral Tough Texas Dust

THESE two gas engines each drive two pumps in tandem, with capacity of 110,000 gpm per unit, for the Lower Neches Valley Authority, Beaumont, Texas. It's a big job. There's no time for down-time.

That's why you see those AAF Cycoil heavy-duty oil bath air cleaners on the job. They provide 4-way cleaning—impingement, scrubbing, cyclonic action and filtering. Over 90% of the fine dust content in the air is trapped in oil and removed by centrifugal action before most of it even reaches the filter pads! Additional action of filtering pads, what's more, plus positive oil circulation for self-cleaning action, provides air that's virtually 100% *dust-free*.

Only Cycoil gives engines and compressors this kind of protection. Write for Bulletin No. 130 . . . the nuts-and-bolts, facts-and-figures story on Cycoil Oil Bath Air Filter!

Type CMS Multi-Duty Filters

Type G Pipeline Air Filters

American Air Filter
COMPANY, INC.
384 Central Avenue, Louisville 8, Kentucky
American Air Filter of Canada, Ltd., Montreal, P. Q.

— BETTER AIR IS OUR BUSINESS —

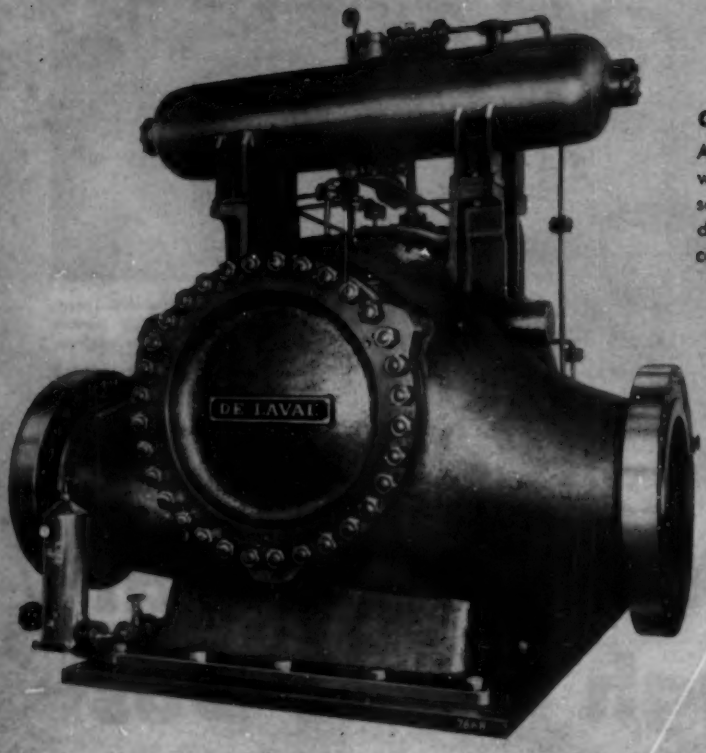
Type OCH Intake Air Filters

Cycoil Oil Bath Air Filters

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

DE LAVAL
CENTRIFUGAL PIPELINE COMPRESSORS

come in two "packages" for easy installation



COMPRESSOR

A De Laval compressor with its emergency seal tank mounted directly on the compressor.

CONSOLE

The console contains the filters, motor-driven pumps, coolers, pressure switches, gauges and other accessories. It eliminates complicated piping on the packaged compressor . . . also serves as a protective cover for the equipment it houses.

Bulletin 503 gives data on De Laval centrifugal pipeline compressors. Write for your copy.

Designed in two packages, rugged De Laval centrifugal compressors offer many important engineering features. Among these are • high pressure contact shaft seal which eliminates gas leakage • heavy and rigid construction throughout • high load carrying capacity. The compressor and console arrangement makes De Laval centrifugal compressors easy to install—only simple low-cost foundations are required. De Laval units, totaling more than 280,000 horsepower, are now in operation on major pipelines.

DE LAVAL *Centrifugal Compressors*

DE LAVAL STEAM TURBINE COMPANY
869 Nottingham Way, Trenton 2, New Jersey

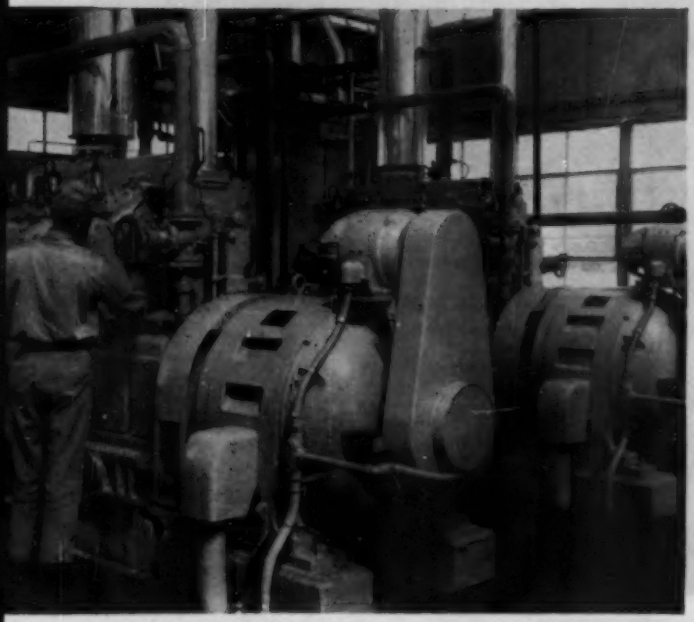
DL-933

a reputation of integrity
skill and dependability...

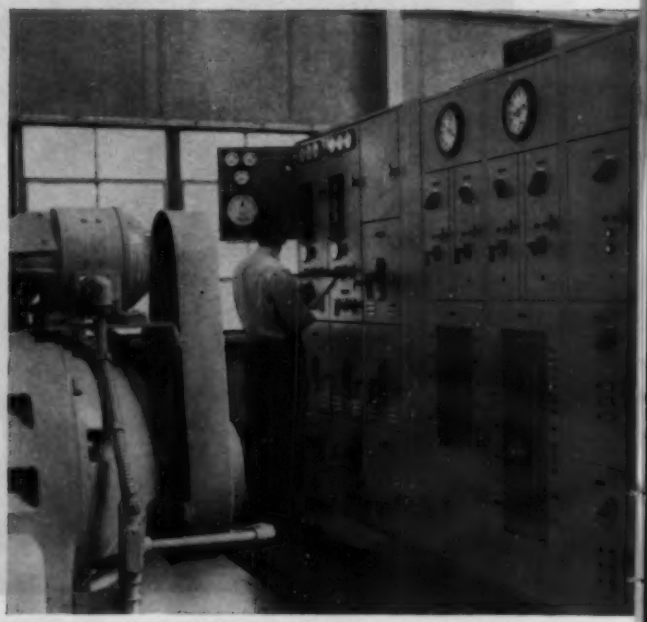
FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Powered by General Electric engineered drive system . . .

Tennessee Gas Transmission uses parallel

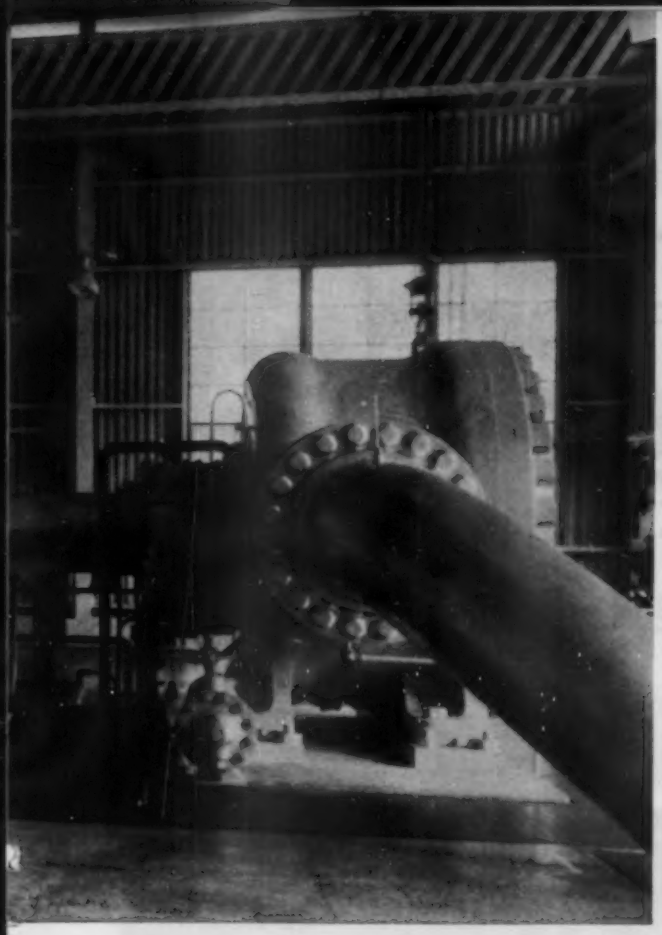


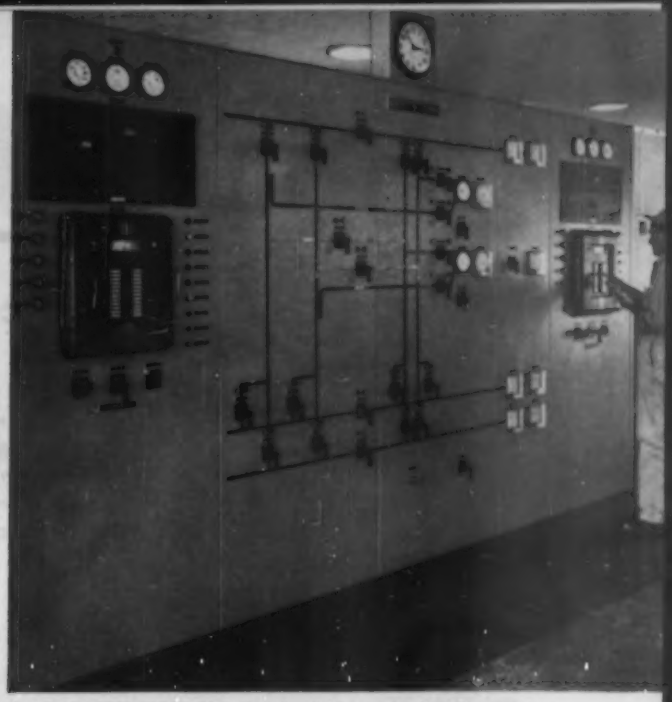
AUXILIARY ELECTRICAL equipment receive power from two General Electric 187-kva, engine-driven, a-c generators which supply 480-volt, 60-cycle power for the station system.



COMPACT, FACTORY ASSEMBLED General Electric Cabinetrol* panel centralizes control of station's auxiliary equipment, was planned to take up minimum valuable floor space.

*Reg. trade-mark of General Electric Co.

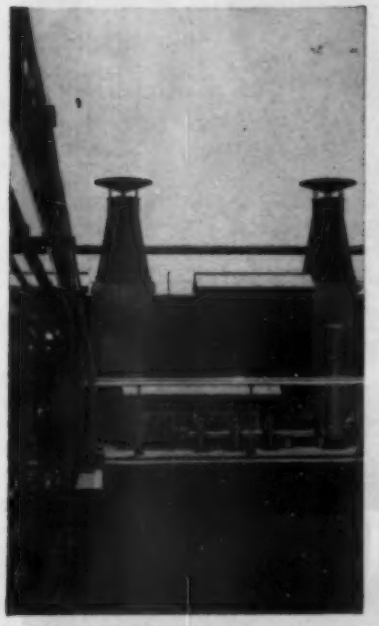




CENTRALIZED CONTROL for the 2 General Electric gas turbines is located in accessible, duplex control panel. Panel provides semi-automatic operation, requires little supervision.

PARALLEL COMPRESSOR ARRANGEMENT, first in the industry, permits two 6700-hp gas turbines to handle station's prime mover requirements for 4-season, lower cost operation.

compressor arrangement in Morehead station



TURBINE EFFICIENCY is increased with regenerators, located outside new station, that "recapture" exhaust heat.

General Electric engineered compressor drive system, with two 6700-hp gas turbines, helps lower new station's operating costs

The Tennessee Gas Transmission Company's new Morehead, Kentucky, pipeline station has two centrifugal compressors arranged for parallel flow, to provide highly flexible operation. With this arrangement—an industry first—the adjustable speed compressors provide a wide range of flows and piping combinations with high stability.

THE DRIVE SYSTEM was installed to meet the station's individual compression requirements and to help lower operating costs. Speed adjustment of the turbines, to meet seasonal increases in compressor load, is easily accomplished. The station has lower maintenance and operator requirements. In addition, the gas turbine fundamental characteristic of increasing horsepower, with decreasing ambient temperature, means that up to 25% more horsepower is available to meet cold weather's increased load requirements.

WHEN YOU EXPAND your compressor facilities, General Electric has a complete line of engineering services also available to you, to help you and your consultants install a drive system engineered for your particular requirements. Your Apparatus Sales Representative, at the nearest General Electric Apparatus Sales Office, will give you complete information. Contact him early and write for bulletin GEA-5962 to General Electric Co., Section 661-54, Schenectady, N. Y.

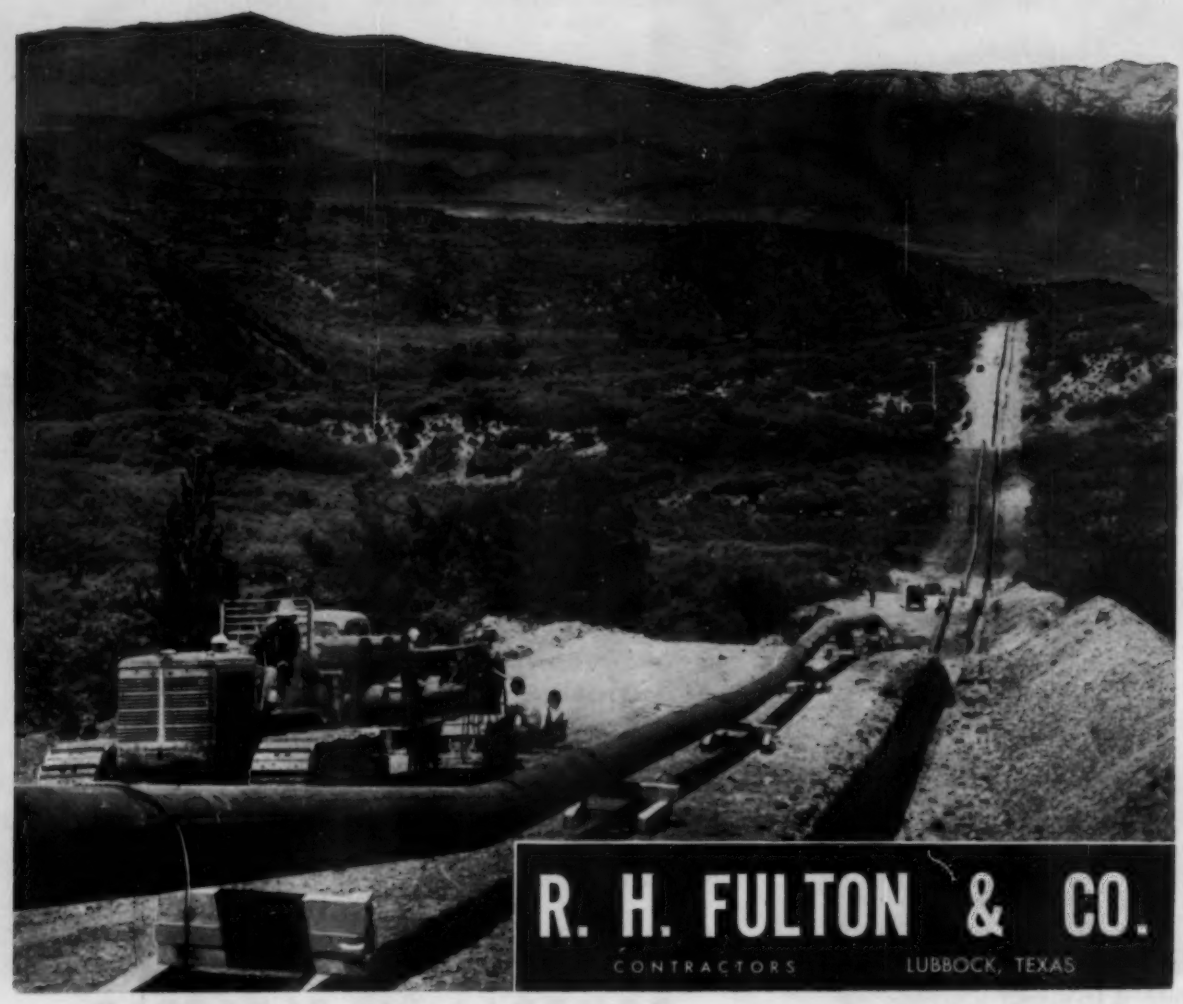
Engineered Electrical Systems for Pipeline Pumping

GENERAL ELECTRIC

PIPELINES

ACROSS THE CONTINENT...

OIL LINES
WATER PIPELINES
RIVER CROSSINGS
PRODUCTS PIPELINES
GAS PIPELINE CONSTRUCTION

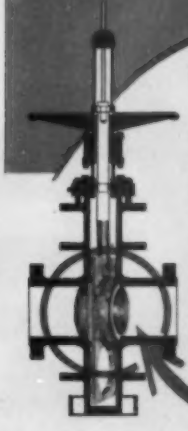


FOR FURTHER INFORMATION ON
ADVERTISED PRODUCTS, SEE READER SERVICE CARD

the gate valve with THROUGH CONDUIT always in line with the line

Shown is 34" full opening high pressure gas line valve. Others 2" to 36" in all standard pipeline pressures for gas or liquid service.

- Solid one-piece parallel-faced gate always moves freely to the same precise full open or closed position
- No wedging to cause wear and consequent misalignment
- Nothing to impede free movement of line cleaning devices



THE WHOLE VALVE IS RIGHT HERE

When valve is full open or closed, bubble-tight seals on both sides of the gate completely isolate line pressure in the conduit. The body, serving merely as framework for operating mechanism and to prevent loss of product while gate is in motion, may be drained or vented to atmosphere when gate is open or closed. Integrity of seals can be checked any time by a tell-tale valve on the body.

GROVE SEAL-"O"-RING Gate Valves

GROVE VALVE and REGULATOR COMPANY • 65th & Hollis Sts., Oakland 8, California
HOUSTON 4 — 1901 Calumet St. • • • • • • • • **LOS ANGELES 6** — 1930 W. Olympic Blvd.

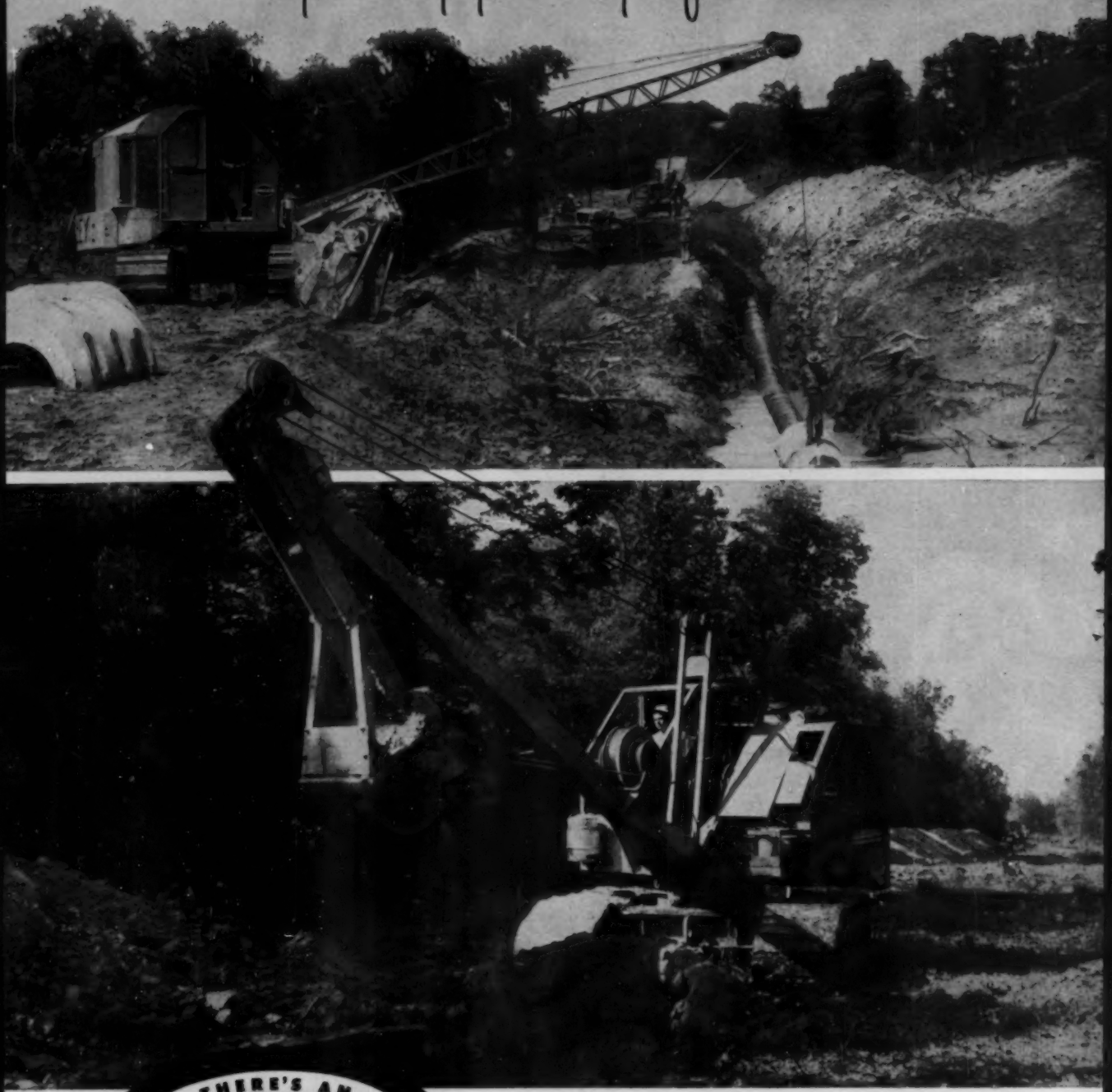
ODESSA, TEXAS • TULSA, OKLAHOMA • DENVER, COLORADO • In Western Canada: GROVE VALVE LIMITED

GROVE SEAL RING — GROVE — SIMPLICITY ACCURACY SAFETY

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

the INSLEY "pipeliner"

...tops in pipeline performance



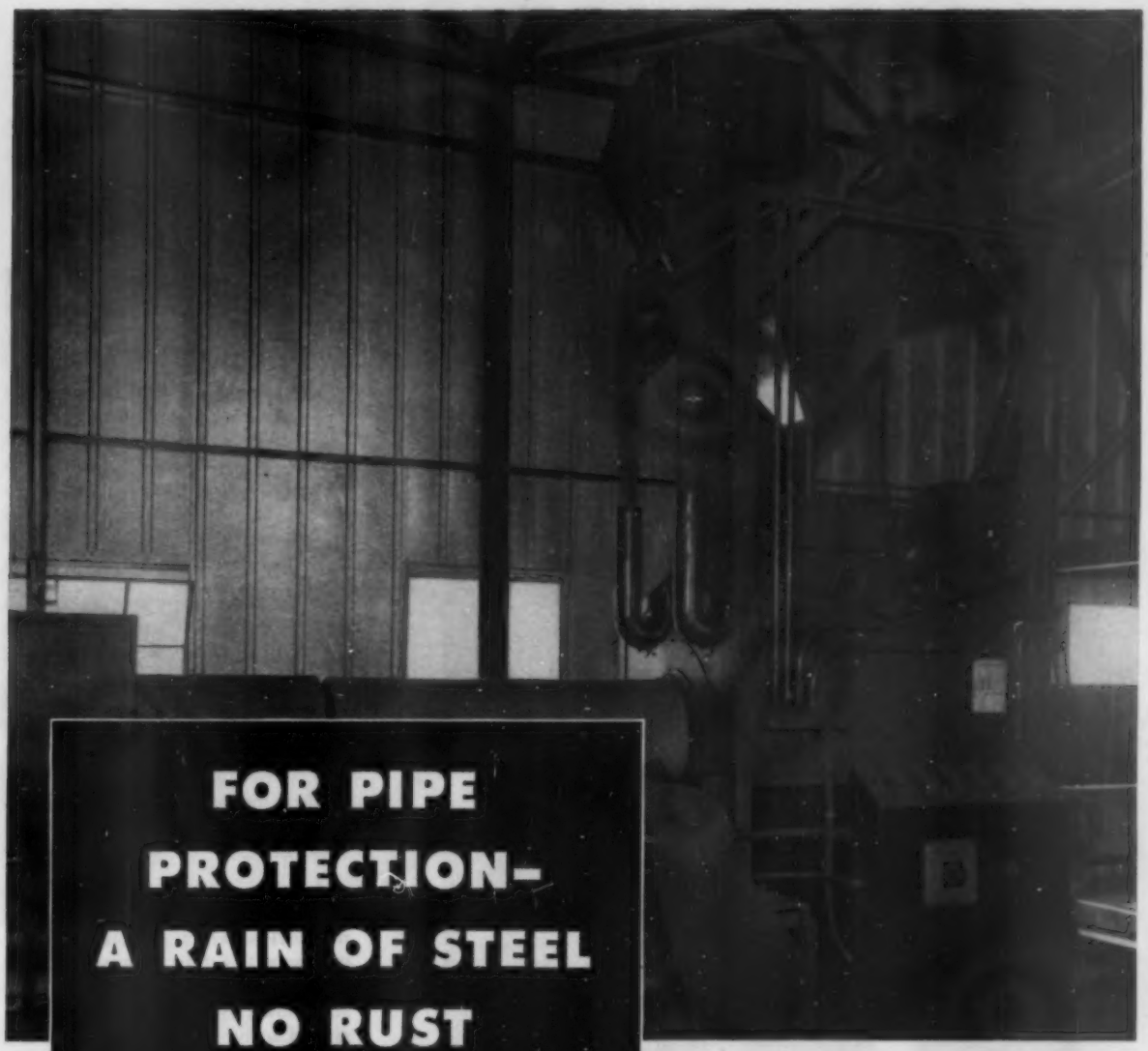
THERE'S AN **INSLEY** WORKING NEAR YOU

Pipeline contractors know Insley as a dependable performer—a machine with "built-in" durability and stamina that will withstand the severe operating conditions of cross-country pipelining.

The Insley "Pipeliner" is fully convertible for hoe, shovel, dragline, clamshell and crane work, and is available with gasoline or diesel power.

INSLEY MANUFACTURING CORPORATION · INDIANAPOLIS 6, INDIANA

wholly owned subsidiary / THE MAXI CORPORATION · LOS ANGELES



FOR PIPE PROTECTION— A RAIN OF STEEL NO RUST CAN RESIST!

This innocent looking machine is a Roto-Grit-Blaster. Especially designed by Hill, Hubbell engineers, it showers the pipe with a high-pressure barrage of steel grits that removes every trace of rust or mill scale. Thus cleaned to bare, bright metal, the pipe is etched to better hold the priming coat in permanent bond between steel and hot coatings. Born of Hill, Hubbell know-how, the Roto-Grit-Process is simply—

Another "first" pioneered by the first name in pipe protection

FACTORY APPLICATORS OF COATINGS AND WRAPPINGS

HILL·HUBBELL & COMPANY

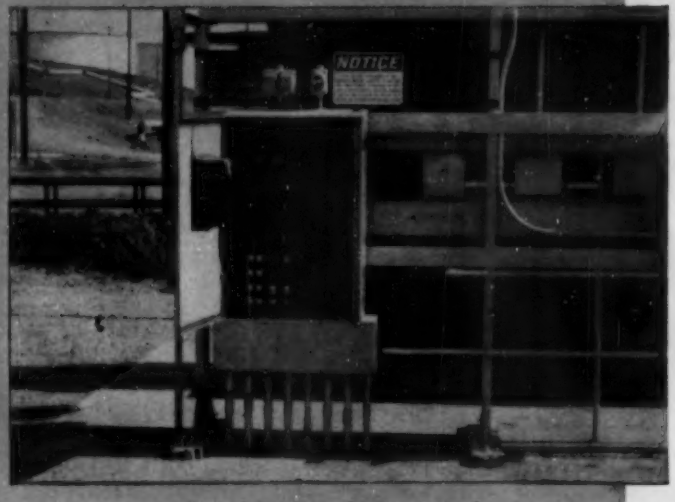
DIVISION OF GENERAL PAINT CORP. • 3091 MAYFIELD ROAD, CLEVELAND 18, OHIO

UNION REMOTE CONTROL

for an oil pumping station

speeds up operations—safely

Control Station at the wharf.



Control Station at the storage tanks.

An unusual installation of UNION remote control equipment was recently made for controlling a pumping station at an oil company wharf.

The pumps are used to transport crude oil from a tanker at the dock to refinery storage tanks on land and vice-versa . . . and to move heated fuel oil to a storage tank and then to the ship for its own use. The pumps are located 1700 feet away and 50 feet above the dock.

With this control system the oil lines from the ship are connected to the dock lines. Then an operator simply pushes a button on the dock to activate the small, compact field equipment, located at the pump site in an explosion-proof housing. This action energizes the pump circuits, starting the pumps. The operator can stop the pumps by pressing another button.

A unique feature of the equipment is the protective circuitry and sensing devices which surround the operation with safety. If pressure is lost at the pump, it will automatically shut down. The equipment was designed to be readily adaptable and easily integrated into an already existing communication system.

This is another example of how UNION Centralized Transport Control can be used to make operations faster and more efficient. Write for complete information, Bulletin 1052.

Quality First . . . TO LAST

75 Years 1881 1956

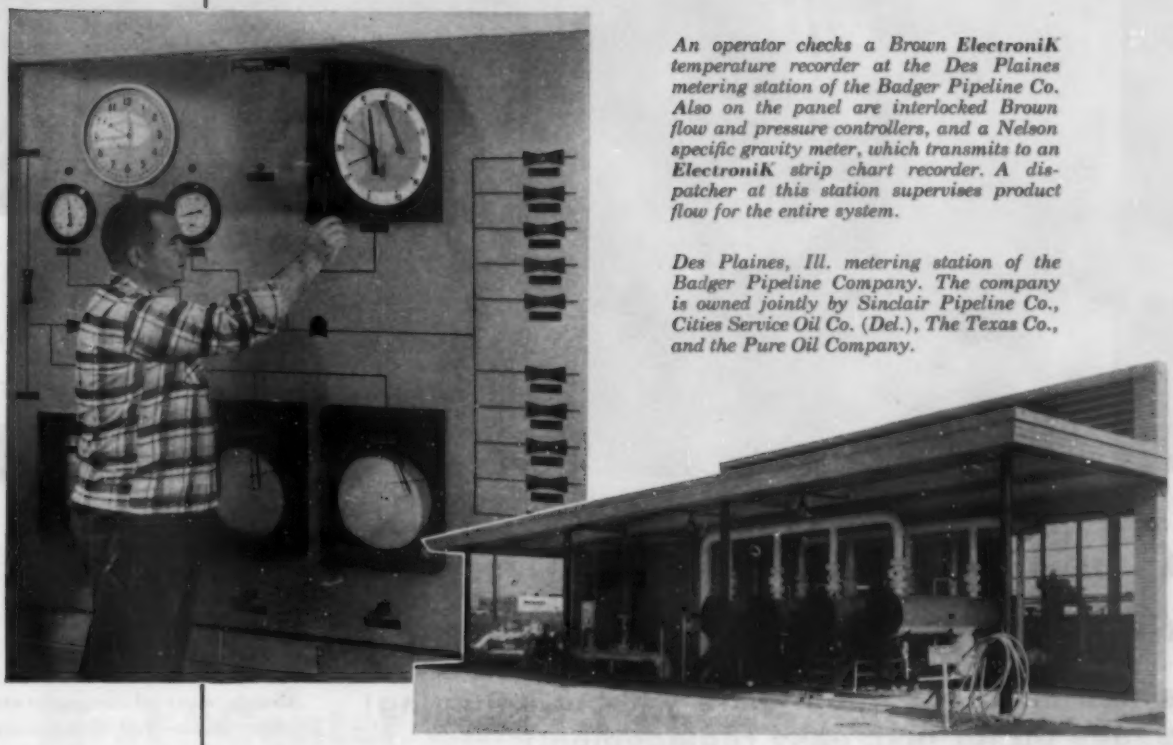
OF EQUIPMENT AND SYSTEMS ENGINEERING . . . . .

UNION SWITCH & SIGNAL

DIVISION OF WESTINGHOUSE AIR BRAKE COMPANY

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Every station on the Badger Pipeline uses Brown instruments



An operator checks a Brown ElectroniK temperature recorder at the Des Plaines metering station of the Badger Pipeline Co. Also on the panel are interlocked Brown flow and pressure controllers, and a Nelson specific gravity meter, which transmits to an ElectroniK strip chart recorder. A dispatcher at this station supervises product flow for the entire system.

Des Plaines, Ill. metering station of the Badger Pipeline Company. The company is owned jointly by Sinclair Pipeline Co., Cities Service Oil Co. (Del.), The Texas Co., and the Pure Oil Company.

AT metering stations, at pumping stations . . . all along the Badger Pipeline . . . Brown instruments keep close watch over temperature, pressure and flow. The Badger Pipeline system serves an area surrounding metropolitan Chicago and northwest to Rockford, Ill. and Madison, Wis.

At the Des Plaines metering station shown above, *ElectroniK* recorders provide accurate temperature and specific gravity information. A Pressure Controller is interlocked with a Flow Controller to position the station control valve. Flow controller input is received from a mercuryless *Differential Converter* transmitter.

Accuracy, sensitivity, and "built-to-take-it" construction make Brown instruments ideally suited for pipeline operations everywhere.

For a discussion of your own pipeline applications, call your local Honeywell sales engineer . . . he's as near as your phone.

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CARTRIDGE SEAL slides off mixer shaft, which uncouples to permit removal. New cartridge goes in its place. Taper on shaft insures correct alignment when recoupling.

Cut mixer maintenance 60%
with this cartridge-type *rotary seal*

Stops leakage! Runs years without adjusting! Slides off for fast, easy replacement!

If you're mixing or blending in big tanks, here's the newest way to slash mechanical mixer upkeep as much as 60%.

For here at last is a rotary mechanical seal—optional on new LIGHTNIN Side Entering Mixers—that stops leakage around the tank, ends stuffing-box repacking and adjusting for good.

And for the first time ever on big-tank mixers, you can replace this seal in a jiffy if you ever have to! No need to dismantle or remove the mixer from the tank. No need to drain the tank. No special skill required!

Even under a full head of liquid in the tank, the seal-change job is so simple it takes only minutes. The mixer shaft retracts to seal the tank, then uncouples. The seal cartridge slides off in one piece. A new cartridge slides on; the mixer shaft automatically realigns itself when recoupled—and you're back in operation.

The LIGHTNIN seal cartridge is a complete unit assembly, easy to stock as a replacement, or quickly obtainable in all sizes and materials, for the simplest or most difficult operating conditions.

Already, many oil companies are using LIGHTNIN Seals—and saving many thousands of dollars per year. Your LIGHTNIN Mixer representative can give you the full story—show you how much *you* can save. Call him today—he's listed in your copy of Refinery Catalog. Or get the facts by mail: send the coupon for 8-page, fully illustrated bulletin.

Lightnin® Mixers
MIXCO fluid mixing specialists

Left: **NO STUFFING BOX** to repack or adjust. No leakage around the tank. When correctly applied, seal runs for years without adjustment. *Right:* **REPLACEMENT** is simple, even with tank full. Mixer shutoff closes like a valve to keep liquid in the tank while seal is being changed.

☐ **Quick! Send us the cost-cutting facts on LIGHTNIN Rotary Mechanical Seals—Bulletin B-111. We'd also like catalog information on these LIGHTNIN Mixers:**

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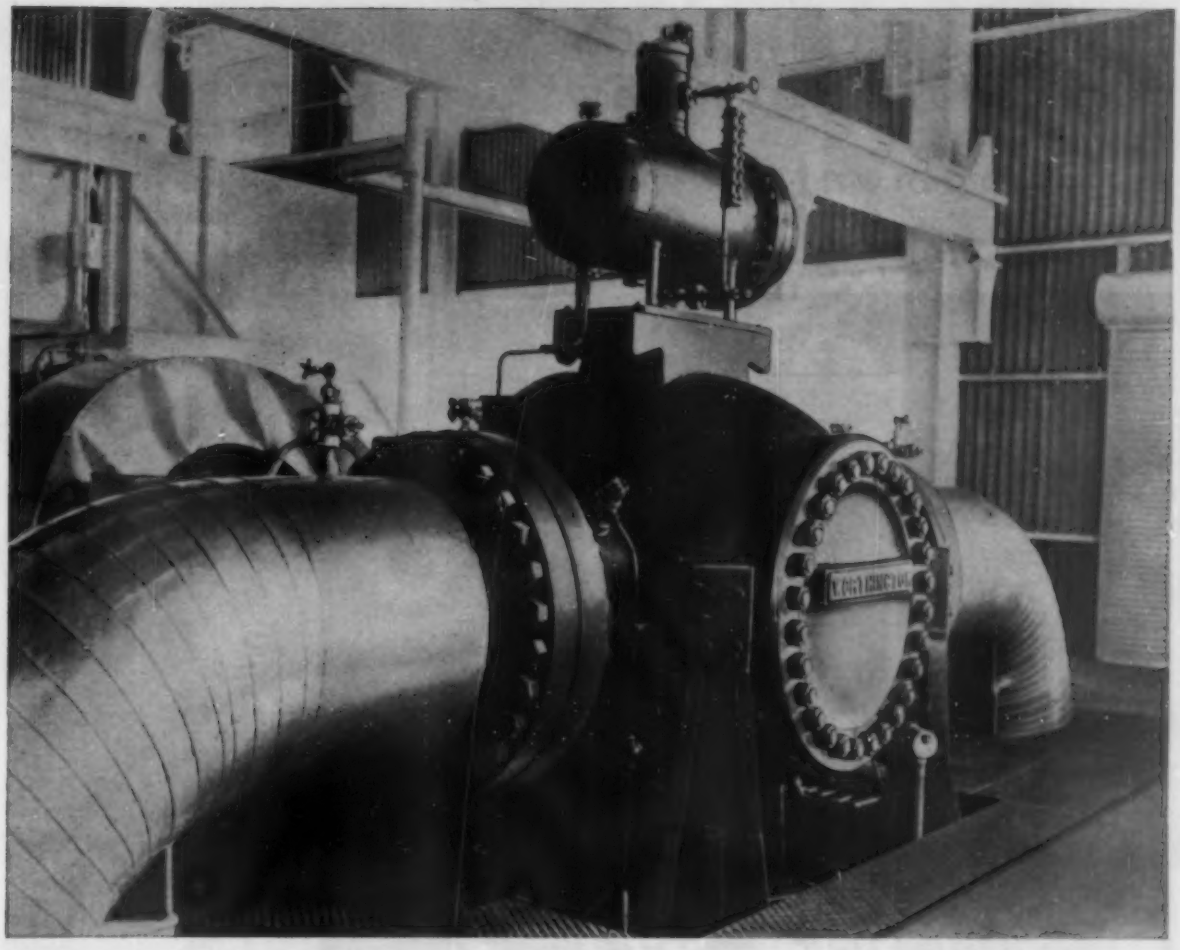

First "Center Line" Centrifugal Booster completes 18 months of pipeline service

Records show "practically no maintenance required"

This "new design" gas pipeline compressor has more than lived up to its advance billing. In service at Northern Natural Gas Company's Macksville, Kansas, station, since December, 1954, it has averaged 800 million cubic feet per day at a pressure of 500 psi. Records show that it has required practically no maintenance.

A brand new idea in compressor design, Worthington's type GUP compressor has a spherical casing supported at the center line. As a result, shaft distortions are minimized, starting stresses reduced, and bearing life extended.

A separate compressor driven pump supplies oil pressure at all times. By adding a cooler, the system may be made completely independent of the driver. A double trap in the scavenging system insures that no seal oil will seep into the gas stream.

It's easy to inspect. No internal part is too heavy for one man. The lightweight impeller, for example, weighs only 100 lbs.

If you'd like more information about this new pipeline compressor, write for bulletin C-1100-B57 to Section E66, Worthington Corporation, Harrison, N.J. In Canada: Worthington (Canada) 1955, Ltd., Toronto, Ontario.

E-6-6

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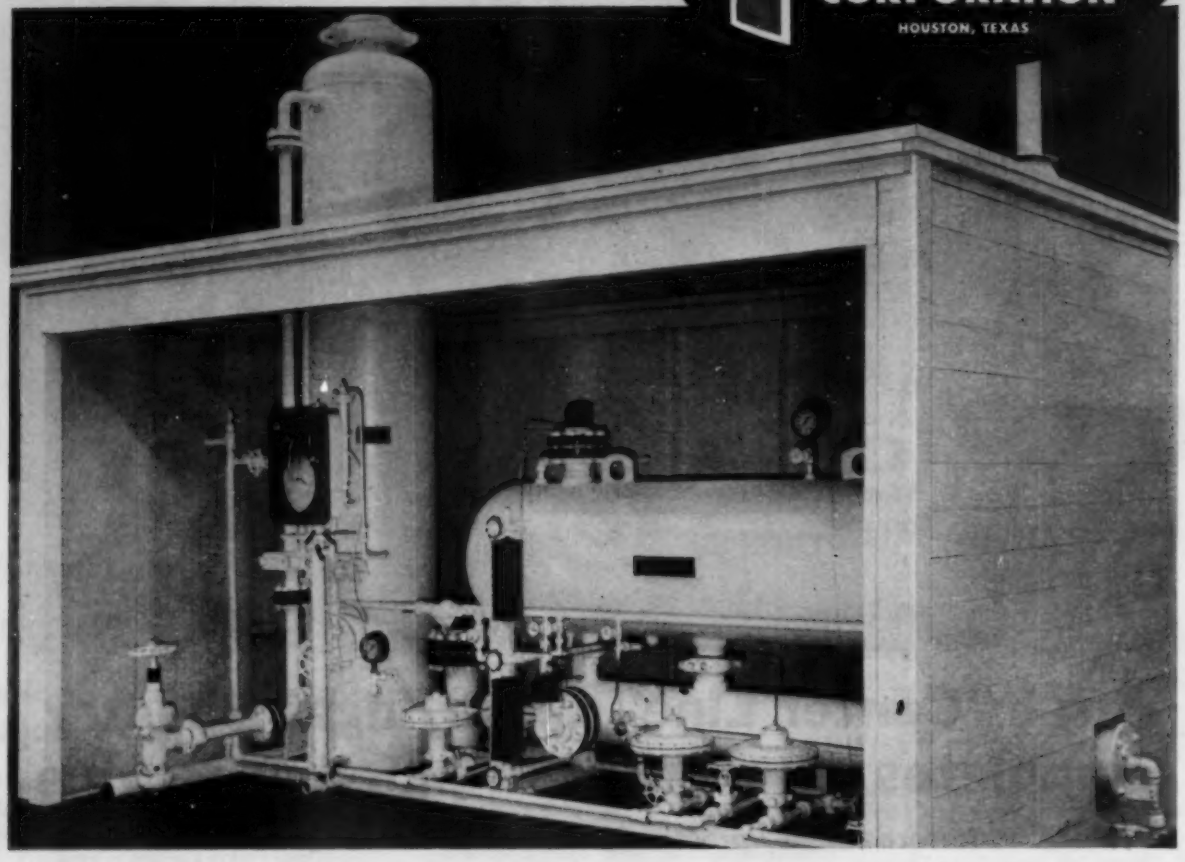

the new FISH well head gas dehydration unit

Here is a revolutionary new gas dehydration unit that greatly reduces overall dehydration costs. The new Fish Unit uses calcium chloride as the dehydration agent in a tower of patented design that removes from two to three times as much water per unit of desiccant as former methods. No fuel is needed for the dehydration tower. No maintenance is required aside from reloading desiccant and changing charts.

The Fish Dehydration Unit is packaged to include a separator, a heater to keep water in the separator above freezing and necessary controls and instruments. The entire unit is enclosed in a winterized structure.

Extensive field tests have proved the efficiency of the Fish Dehydration Unit even in severe winter climates. For full information, write Fish Engineering Corporation, Manufacturing Division, Aztec, New Mexico.

AFFILIATED COMPANIES: FISH ENGINEERING CORPORATION, HOUSTON, TEXAS
FISH SERVICE & MANAGEMENT CORP.: FISH NORTHWEST CONSTRUCTORS, INC.

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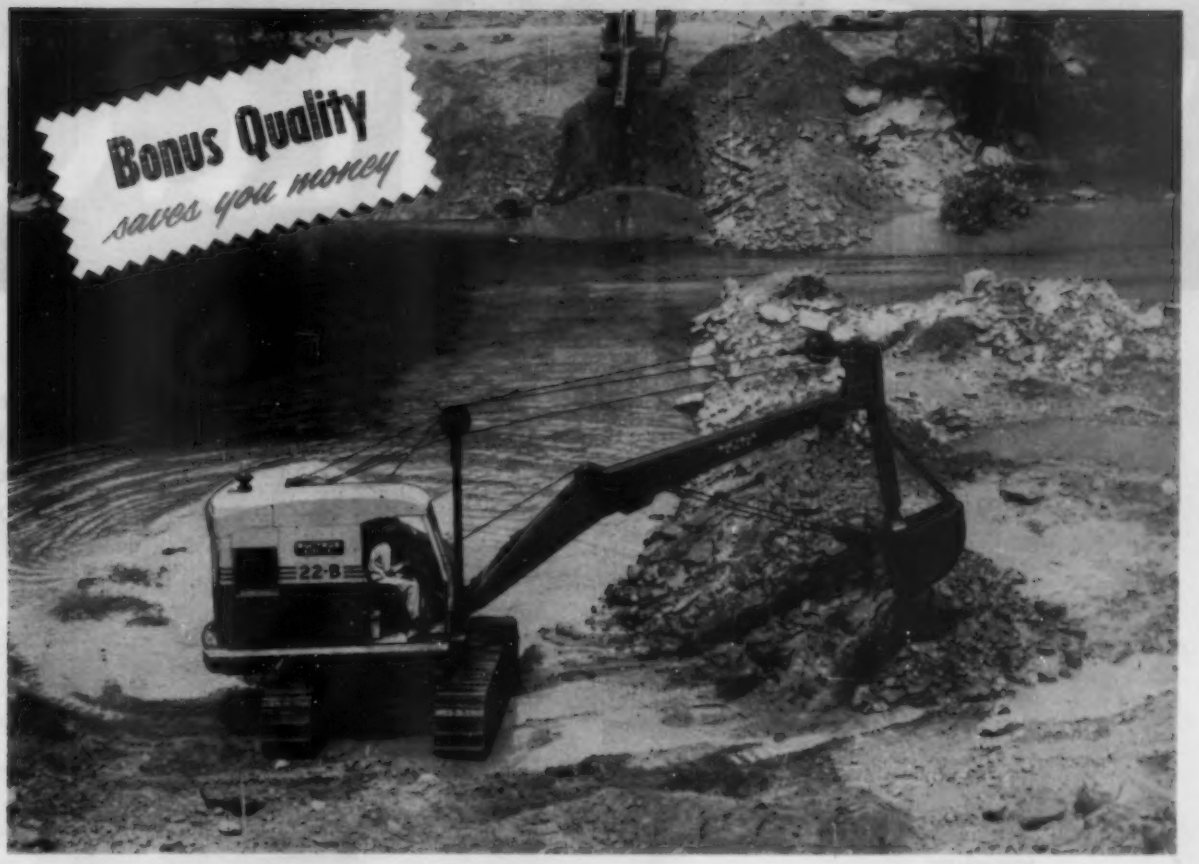

Help your spreads *stay on schedule...*

EQUIP THEM WITH DEPENDABLE, FAST-DIGGING BUCYRUS-ERIE DRAGSHOVELS

When you put sure-footed, high-output Bucyrus-Erie 15-B and 22-B dragshovels in the hands of experienced pipeliners, you've got a combination that's *geared to move on schedule.*

For the greater mobility needed by pipeliners, special mounting with tractor-type crawlers having deep grousers is available for these machines at extra cost. It provides the traction and mobility to cover rough terrain, enables these machines to climb grades up to 35 per cent, and to maneuver through swamps and mud. Clearance is high, too, for easy travel over rocks and obstacles — up to 16½ in. for the 15-B, and 20¾ in. for the 22-B.

A powerful digging stroke plus rapid hoist and swing produce consistently high output even in hard digging. Just as important is Bucyrus-Erie's traditionally sound and proved design that insures maximum working time and keeps maintenance to a minimum.

Your nearby Bucyrus-Erie distributor will give you the complete story on the dragshovels that experienced pipeliners depend on — the ½-yd. 15-B and ¾-yd. 22-B. See him soon. 237E56

Bonus Quality Bucyrus-Erie leaves nothing to chance. This sample pouring from a furnace will be tested to insure that it measures up to the highest specifications. This testing is done with *all* steel used by Bucyrus-Erie — your assurance of the Bonus Quality that means money saved day after day, year after year.

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Philco Series 500 Package is designed primarily for pipe line and railroad companies requiring maximum dependability consistent with highest commercial performance standards along extensive right-of-way routes.

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- Expandable to 24 or more channels (plus service channel)
- Extendable to 40 hops (1000 miles)
- Commercial quality circuits

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Philco Series 120 Package is designed to provide low cost, reliable communications over moderate distances for turnpikes, police, and utilities.

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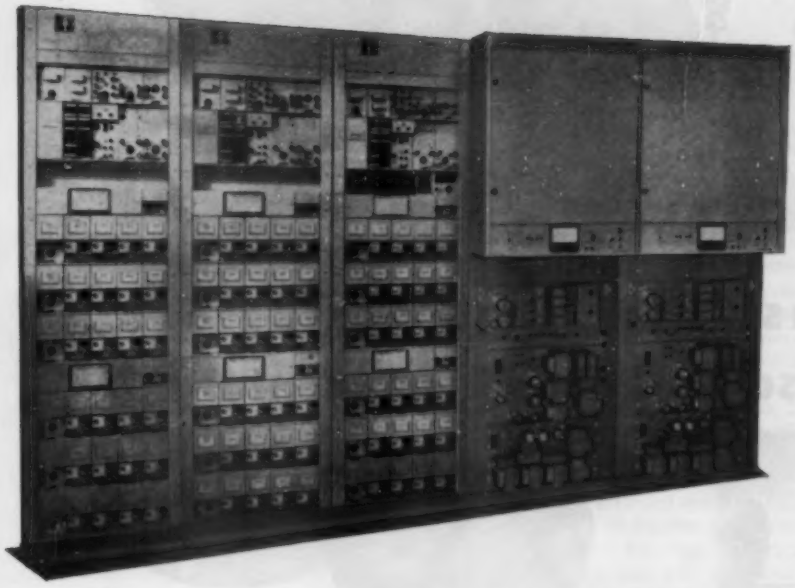

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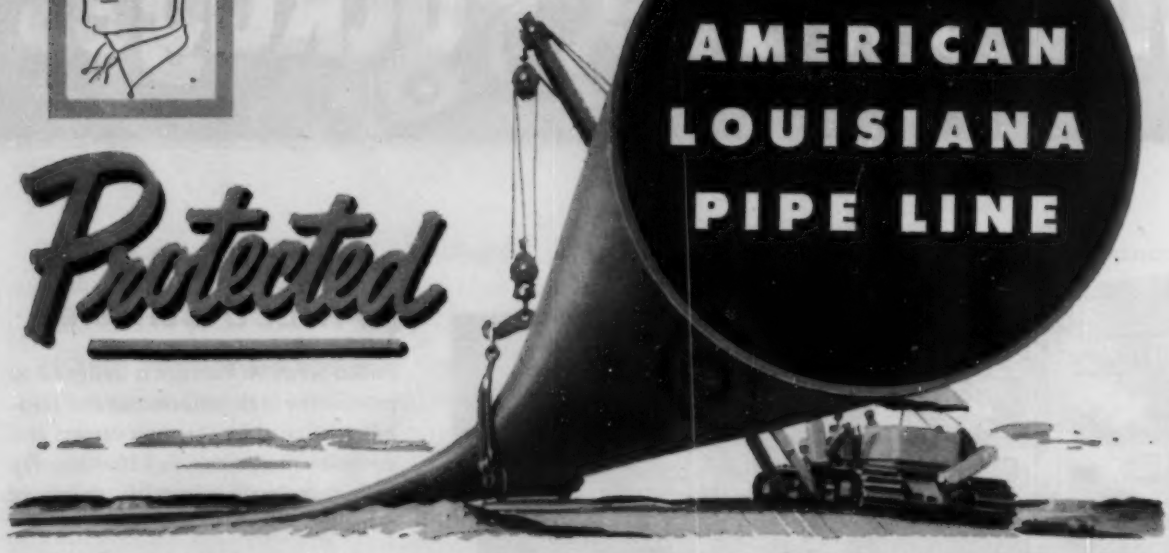

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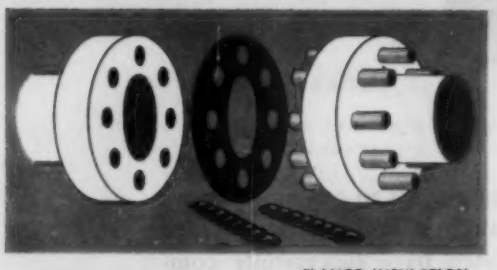

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SINCE 1932 — PRECISION IN RUBBER — METAL — PLASTICS

Construction Report: 1956

18,756 miles of pipe line built or underway
23,461 miles of line planned or proposed

A Pipeline Engineer Staff Report

THE saturation point for pipe line construction is nowhere in sight. The rapid rate at which steel pipe has gone into the ground in the past 10 or so years could understandably lead to the conclusion that the big activity must be nearing an end. Based on a survey just completed by *The Pipeline Engineer*, the facts do not bear this out.

The comprehensive survey, conducted for this annual October "Construction Issue' shows for the preceding 12-month period, there are 18,756 miles of crude, products, and gas pipe lines already built or still under construction. In a similar survey made a year ago by this publication, the figure stood at 15,136 miles.

As has been the case for many years, gas pipe line mileage outstrips by far that of crude and products. Gas lines built or under construction total 13,670 whereas for crude oil the mileage is 2256 and for products, 2807. Gas is being made available for the first time to new consuming areas both in the United States and Canada.

The outlook for the coming 12 months is good. In fact, proposed and planned lines exceed a year ago by approximately 4000 miles. The survey shows 23,461 miles in the planned and proposed category as compared with 19,305 on October 1, 1955. Included are 15,622 miles of gas lines, 4535 miles of crude oil lines, and 3304 miles of products lines.

Canada is contributing importantly to this bright pipe line picture. Only about 400 miles of cross-country pipe line were laid in the Dominion during 1955. For the current year the total will approximate 1200 miles. Because of the comparative newness of the petroleum industry in Canada, even more rapid growth is anticipated for the future. A member of Parliament, Carl O. Nickle, predicts that in the next five years 1500 miles of crude oil lines and 5500 miles of gas lines will be constructed in Canada. He further predicts that Canada will build 15,500 miles of pipe lines of all kinds in the next 10 years if the industry is free to expand without too much control.

Gas Line Construction

Outstanding gas line competition of the year was the Pacific Northwest Pipeline Corporation system from the San Juan Basin to Sumas, Washington. With laterals and gathering lines, this project total 2287 miles. Colorado Interstate, which will take a part of the pump load, is laying a 380-mile, 22-in. line from Denver to Green River, Wyoming. At Sumas, Westcoast Transmission will deliver Canadian gas into the Pacific Northwest system. The complete Pacific Northwest story appears in this issue of *The Pipeline Engineer*, written by the men who built and who will operate the system.

American Louisiana Pipe Line Company has completed its 30-in. mainline from Cameron, Louisiana, to Willow Run, Michigan, a distance of 1289 miles, and presently is laying 117 miles of 22-in. laterals to Bridgman, Michigan, and Defiance, Ohio, which will be completed this year.

Transcontinental Gas Pipe Line Corporation has entered upon its third major mainline looping program. In all, 336 miles of pipe will be laid, extending into 1957. At present, spreads are working in Louisiana and Maryland.

Tennessee Gas Transmission Company will complete this fall a $56,000,000 program, consisting of parallel lines, additional compressor horsepower, and what is colorfully called "the Muskrat Line." The latter is a network of gathering lines in marshlands and swamps of Louisiana that connect with onshore and offshore wells.

Texas Gas Transmission Corporation is expanding its system by adding 226 miles of loop and 30,970 compressor horsepower.

Texas Eastern Transmission Corporation has increased its flexibility and added to capacity by laying a 379-mile, 30-in. line from Beaumont, Texas, to Kosciusko, Mississippi, constructing eight new compressor stations, adding to existing stations, and laying approximately 100 miles of smaller diameter laterals and connecting lines.

Work begins this month (October) on 241 miles of 30-in. between Newhall and Needles for Southern California and Southern Counties Gas companies. A 49-mile line from Alhambra to Newhall, which will connect with the Newhall-Needles line, has been under construction for some time and is expected to be completed by December 1.

After many disappointing delays, Trans-Canada Pipe Lines, Ltd., finally got its marketing, and political problems ironed out and moved off to a fast start on the 576-mile section of 34-in. line between Burstall, Saskatchewan, and Winnipeg, Manitoba. This section will not be completed until sometime in 1957. Later the line will be extended to Montreal. The overall project will consist of 2250 mailes of 30 and 34-in.

First major gas line to get underway in Canada was that of Westcoast Transmission Company, Ltd., extending from the Peace River area of Alberta, to Sumas, Washington, where it will deliver gas to the Pacific Northwest system. The project is scheduled for completion in about a year. Mainline, laterals, and gathering lines will total approximately 1472 miles of 10 to 30-in. pipe.

Crude Line Construction

In comparison with 1955, fewer miles of crude oil pipe lines will be built this year. With the exception of Butte Pipe Line, completed in February, there have been no long lines laid.

The Butte line was well along in

construction when this report was made a year ago, and was completed soon after the first of 1956. This 507-mile, 6 to 16-in. system extends from Poplar to Ft. Laramine-Guernsey, Wyoming.

Among the large projects completed or underway are:

The Buckeye Pipe Line Company — reconditioning of 191 miles of 8-in. between Griffith, Indiana, and Lima, Ohio.

Cremona Pipe Lines, Ltd. — 87 miles of 8-in. from the Sundre-Westward Ho area to Calgary, Canada.

Interprovincial Pipe Line Company — 69 miles of 24 and 26-in. from Cromer, Manitoba, to the Canadian-U. S. border.

Interstate Oil Pipe Line Company — 86 miles of 4, 8, and 12-in. in Louisiana.

Pasotex Pipe Line Company — 68 miles of 20-in. loops between Wink, New Mexico, and El Paso, Texas.

Powderriver pipeline, Inc. — 108 miles of 6-in. from Sumatra to Billings and Laurel, Montana.

Salt Lake Pipe Line Company — 83 miles of 10-in. loops.

Sinclair Pipe Line Company — 151 miles of 18-in. from Jacksboro to Teague, Texas.

Westspur Pipe Line Company—174 miles of 4 to 12-in., in Saskatchewan and Manitoba, Canada.

Winnipeg Pipe Line Company — 73 miles of 10-in. from Gretna to Winnipeg, Manitoba.

Products Line Construction

Again this year products line construction exceeds crude.

Southern Pacific Pipe Lines placed its system on stream early in the year. In January, the 8-in. line from El Paso, Texas, was completed. The following month, the 16-in. from Watson to Colton, California, and the 12-in. from Colton to Phoenix, Arizona, was in the ground. This completed the main portion of the system, but in April, 6-in. supply lines to Air Force bases in Arizona and California were completed. In all, the project represented about 1024 miles of pipe line.

Before the end of the year Plantation Pipe Line hopes to have its present work finished, which will increase capacity by 60,000 bbl a day. An 18-in. loop is being laid from Baton Rouge, Louisiana, to Helena, Alabama, to parallel existing 12 and 18-in. lines. This distance is 327 miles. Pumping facilities are being increased at Baton Rouge and more tankage provided.

Sun Pipe Line Company is replacing a line between Twin Oaks, Pennsylvania, and Newark, New Jersey, with a 109-mile, 14-in. which is scheduled for completion this month.

Cosden Petroleum Corporation added 10 miles to its network this year, laying 103 miles of 6-in. from its Big Spring, Texas, refinery, to Abilene, and 7 miles of 5-in. to Webb Air Force Base.

Magnolia Pipe Line Company reconditioned a line from Corsicana to DeLeon, Texas, 123 miles of 8-in. Under construction are 30 miles of 8-in. from Dollarhide to Andrews, Texas; 22 miles of 4 and 6-in. between Beaumont and Orange, Texas, and 75 miles of 8-in. from Hill to Texas City, Texas.

Gulf Refining Company has an extensive program underway. The work includes 64 miles of 4 and 8-in. from North Scurry County to Big Springs, Texas; 47 miles of 4 and 6-in. from its Wadell gasoline plant to Midland, Texas; 92 miles of 4 and 8-in. from Monument, New Mexico, to Midland, and 116 miles of 10-in. from Lufkin to Barbers Hill, Texas.

What's Ahead?

It is not likely that all of the 23,461 miles of pipe lines "Proposed and Planned" will be constructed during the next 12 months. In the case of gas lines, some of the projects have not been approved by the FPC. Certain other projects depend upon financing and various factors. It is a certainty, however, that a large part of the proposed lines will be laid to make 1957 a good pipe line year.

Gas Lines. Tennessee Gas Transmission Company, late in September, announced the filing of an application with FPC for a construction program costing $166,000,000, which would add 456,000,000 cu ft to the daily capacity of the system. The new facilities, when added to those now in service, under construction, or covered by pending FPC applications, would increase the company's average-day capacity to about 2½ billion cu ft. The program includes the laying of 1085 miles of line and construction of six new compressor stations and enlargement of seven others. Total added horsepower would be 127,240.

Colorado Interstate is asking to amend its Beatrice Project. The hearing is now taking place before FPC. The new proposal, which will be for a two-year period, includes laying 734 miles of 23 to 30-in. pipe and addition of 60,980 compressor hp. Total cost of the project is estimated at $87,000,000.

Trans-Canada has made a good start on the 576-mile section from Burrstal, Saskatchewan, on the Alberta border, to Winnipeg. This section constitutes only a minor part of the overall project. When and if the line is completed as planned it will extend to Montreal and will consist of some 2250 miles including laterals.

When the Canadian government agreed to help finance the first leg of the line to Winnipeg, it was with the stipulation that it would be completed by the end of 1956 and the loan repaid by April 2, 1957. These requirements must be met before the rest of the line can be built.

Coastal Transmission Corporation has just announced finalizing of gas supply contracts to more than fill its 20-year requirements, strengthening its application now pending before the FPC. Coastal proposes a gathering system in the Rio Grande Valley of Texas and 562 miles of mainline from McAllen to Baton Rouge, Louisiana. At the latter point it will connect with the proposed Houston Texas Gas and Oil Corporation line extending to Miami, Florida. The Houston Texas Gas system will consist of 961 miles, including mainline and laterals.

Midwestern Gas Transmission Company's application is still pending before FPC. The application asks for 1112 miles of 12 through 24-in., extending from the U. S.-Canadian border near Emerson, Manitoba, and Noyes, Minnesota, southward to Portland, Tennessee. In addition, there would be some 648 miles of laterals from the mainline to serve communities in Minnesota, North Dakota, and Wisconsin. This proposal is being opposed by a number of gas transmission and distribution companies who assert Midwestern would enter customer territory already served by them.

Not yet given the "go ahead" sign is Offshore Gathering Company's plan to lay a gas line and a crude oil line parallel in the Gulf of Mexico from Sabine Pass near Port Arthur, Texas, to a point just east of the Pearl River in Mississippi. The two lines would be about 800 ft apart and about 25 miles off the Louisiana coast. Each would be 364 miles in length.

Permission to build the gas line awaits FPC approval. If it should be denied neither line will be constructed. Purpose of this proposed project is to serve the ever-growing number of wells being drilled offshore in the Gulf of Mexico.

A number of other transmission companies have extensive projects planned, some of which are:

Michigan Wisconsin Pipe Line Company, 495 miles of 4 through 24-in.; Natural Gas Pipeline Company of America, 908 miles of 20, 26, 30, and 36-in.; Northern Natural Gas Company, 781 miles of 10 through 24-in.

Northern Plains Natural Gas Company, 1100 miles of 26-in. This company is a subsidiary of Northern Natu-

ral and proposes to construct a pipe line from the Alberta-Montana border to Mineapolis, Minnesota; Pacific Gas and Electric Company, 233 miles of 12 through 34-in.; Southern Counties Gas Company and Southern California Gas Company, 241 miles of 30-in.. Newhall to Topock, for which contracts have just been let; Tennessee Gas Transmission Company, 262 miles of 26 and 30-in. Texas Eastern Transmission Corporation, 1159 miles of 10 through 30-in.; Trans-Carolina Pipe Line Corporation, 840 miles of 2 through 18-in.; Transcontinental Gas Pipe Line Corporation, 232 miles of 30 and 36-in.

Products Lines. Sometime in 1957, Hydrocarbons Pipe Line, Ltd., expects to begin construction of a products line from Alberta to lakehead points, a distance of approximately 800 miles. The pipe line company, a subsidiary of Canadian Hydrocarbons, Ltd., will transport propane, natural gasoline, butane, and other hydrocarbons through Winnipeg as far as the lakehead, from where they will be moved by tanker to eastern Canada. Approval of the Federal Board of Transport Commissioners and the Alberta Conservation Board of Transport Commissioners and the Alberta Conservation Board will have to be obtained before construction can start.

Northwest Pipeline Corporation, affiliated with Pacific Northwest Pipeline Corporation, plans to build a 350-mile, 8-in. pipe line from the Four Corners Area to Salt Lake City, Utah. The system will carry both products and crude oil. The line will originate at the Pacific Northwest Ignacio gasoline plant south of Durango, Colorado.

Southern Pacific Pipe Lines, Inc., has indicated its intention of getting further into the pipe line business by constructing a products line from the Richmond, California, refining area to Fallon, Nevada. The line will be of 6 and 10-in. pipe, 315 miles in length.

Conversion of the "Little Inch" by Texas Eastern from gas to products is still a moot question. A year ago when this report was made FPC had granted permission for such conversion. Soon afterward, however, objections were raised by barge companies and another pipe line seeking permission to serve the same areas. Permission has been suspended and the outcome is yet to be decided. This system extends from Beaumont, Texas, to Moundsville, West Virginia.

Crude Oil Lines. The possibility of a crude oil pipe line across Europe has caused quite a stir in pipe line circles. The Royal Dutch Shell Group has this project under consideration. The main line would extend from Marseille, France, through eastern France, Luxembourg, the Saar, West Germany, Holland, and Belgium, to the North Sea ports of Rotterdam and Antwerp. Oil to be moved would be brought to the southern terminus of the line by tanker from the Middle East. The 30-in. line would be some 870 miles long, and would have a rated capacity of 280,000,000 bbl a year.

Several other lines of sizeable proportions have been announced. Already discussed under products lines is Northwest Pipe Line Corporation's system from Four Corners to Salt Lake City, to be used both as a crude oil and refined products carrier. Offshore Gathering Company's 364-mile twin gas and crude lines in the Gulf of Mexico also were detailed under gas proposals.

Interprovincial Pipe Line Company plans considerable work in Canada, about 183 miles of 20 and 24-in. Humble Pipe Line plans 100 miles of 18-in. from Ector to Kemper, Texas. Pasotex Pipe Line will add a new loop on its system between Wink, New Mexico, and El Paso, Texas, 127 miles of 20-in.

Sinclair Pipe Line Company plans to lay a 20-in. line from Teague to Houston, Texas. The company laid an 18-in. line from Jacksboro to Teague this year.

Union Oil Company of California is making plans for future transportation from the Rifle, Colorado, shale oil plant. When exploration of this shale deposit is commercially feasible Union Oil intends to be ready to start construction of transportation facilities. Mileage of the line would be about 815 to the Los Angeles area. Union plans soon to begin construction on 225 miles of 12 and 16-in. from its Junction station in the San Joaquim Valley to San Francisco, California.

Other projects, both large and small, will provide crude oil pipe line construction of sizeable proportions.

A complete tabulation of pipe lines "Planned and Proposed" and "Built and Underway" is given in the following tables.

Proposed or Planned Pipe Lines

The following tables list the company, mileage, pipe size, and location of proposed pipe line projects — crude, products, and natural gas — reported to *The Pipeline Engineer*. Company addresses are given when known.

CRUDE LINES

Name of Company	Miles	Size	Location
Canadian Gulf Pipe Line Company Tulsa, Oklahoma	35	—	Drumheller field to Big Valley
Humble Pipe Line Company Houston, Texas	100	18	Ector to Kemper, Texas
Interprovincial Pipe Line Company Toronto 1, Ontario, Canada	151	20	Sarnia to Port Credit, Ontario
	32.6	24	Regina, Saskatchewan, to Cromer, Manitoba
Interstate Oil Pipe Line Company Shreveport, Louisiana	5.1	4	South Bosco field, Louisiana, to mainline
	4.9	Var.	Church Point field, Louisiana, to mainline
	16.5	12	Pelican Island to Lake Washington, Louisiana
Kaybee Pipe Line Company Muskegon, Michigan	46	10	Griffith, Indiana, to New Buffalo, Michigan
Lakehead Pipe Line Company, Inc. Toronto 1, Ontario, Canada	80	26	Loop from Clearbrook, Minnesota, to Superior, Wisconsin
Northwest Pipe Line Corporation Houston, Texas	350	8	Four Corners area to Salt Lake City, Utah
Offshore Gathering Company Houston, Texas	364	20	Gulf of Mexico from Sabine Pass to Mississippi River
Pasotex Pipe Line Company El Paso, Texas	127.5	20	New loop on system from Wink to El Paso, Texas

Name of Company	Miles	Size	Location
Pembina Pipe Line Company Calgary, Alberta, Canada	—	—	Sundre-Westward Ho area to Edmonton
Rangeland Pipe Line Company	44	6–12	Central Alberta to Rimbey
Royal Dutch Shell Group and Others The Hague, Netherlands	870	30	Marseille, France, to Rotterdam and Antwerp, Holland
	150	20	Mexia to Houston, Texas. Replacement of existing line
	12	6	North Madill field to Cumberland field terminal, Oklahoma
Royal Pipe Lines, Ltd. Regina, Saskatchewan, Canada	288	Var.	Cantuar area fields to Glenavon
Shell Oil Company Los Angeles, California	1.2	4	Macson Oil Company to Richfield Oil Company line
Sinclair Pipe Line Company Independence, Kansas	150	20	Teague to Houston, Texas
Socony Mobil Oil Company de Venezuela and Sinclair Oil & Refining Company	211	20	Silvester field near Barines to Puerta Cabello, Venezula
South Saskatchewan Pipe Line Company Regina, Saskatchewan, Canada	—	—	Dollard to Cantuar
Stanmount Pipe Line Company	140	10	Beaver Lake field, North Dakota to Cromer, Manitoba
Tecumseh Pipe Line Company Independence, Kansas	190	20	East Chicago, Indiana, to Cygnet, Ohio
Trans-Border Pipe Line Company	110	—	Skagway, Alaska, to Whitehorse, Yukon Territory
Trans-Prairie Pipe Lines, Ltd. Winnipeg, Manitoba, Canada	17	3–6	Lines in Cromer and Virden areas, Manitoba
Union Oil Company Los Angeles, California	815	—	Shale oil plant at Rifle, Colorado, to Los Angeles area (being considered)
	225	12–16	Junction station to San Francisco, California

PRODUCTS LINES

Name of Company	Miles	Size	Location
Buckeye Pipe Line Company New York, New York	17	12	Berea to Cleveland, Ohio
Crescent Corporation Tulsa, Oklahoma	120	6	Tioga, North Dakota to U. S.-Canadian Border
El Paso Natural Gas Company El Paso, Texas	96.0	8	Gallup to Blanco Plant, New Mexico
Equitable Gas Company and Subsidiaries Pittsburgh, Pennsylvania	100	4–5	Maytown, Kentucky to Institute, West Virginia
Hydrocarbons Pipelines, Ltd. Winnipeg, Manitoba, Canada	800	6–8	Alberta to Lakehead
Northwest Pipeline Corporation Houston, Texas	350	8	Four Corners area to Salt Lake City, Utah
Phillips Petroleum Company Bartlesville, Oklahoma	66	12	Loop line from Borger, Texas, to Cassoday, Kansas
	26	12	Loop line from Jefferson City, Missouri, to Eureka, Missouri
Shell Oil Company Los Angeles, California	16.5	4	Convert 13 miles of existing line and construct 3.5 miles new line from Wilmington Refinery to Los Angeles Marketing Depot
Southern Pacific Pipe Lines, Inc. Los Angeles, California	315	6–10	Richmond, California, to Fallon, Nevada
Texas Eastern Transmission Corporation Shreveport, Louisiana	1168	16–20	Conversion of "Little Inch" between Beaumont, Texas, and Moundsville, West Virginia
Winnipeg & Central Gas Company Winnipeg, Manitoba, Canada	210	6	U. S.-Canadian border to Winnipeg

GAS LINES

Name of Company	Miles	Size	Location
Alberta Gas Trunk Line Company, Ltd. Calgary, Alberta, Canada	34	18–34	Bindloss, Alberta, to Saskatchewan border
Andes Pipeline Corporation	500	12	Villamontes, Bolivia, to Antofagasta, Chile
Carolina Natural Gas Corporation Hickory, North Carolina	185	2–12	Additions in North and South Carolina
Central Kentucky Natural Gas Company Charleston, West Virginia	.5	20	Replacement in Boyd County, Kentucky
	.4	12	Additions to system
	5.7	4	Replacement in Montgomery County, Kentucky
Cities Service Oil Company Bartlesville, Oklahoma	70	—	Gas gathering system on the Roberts Ranch, Midland, Texas
Coastal Transmission Corporation Dallas, Texas	562	22–26	McAllen, Texas, to Baton Rouge, Louisiana
	272	Var.	Gathering lines in Rio Grande Valley, Texas
Colorado Interstate Gas Company Colorado Springs, Colorado	345	30	Kit Carson, Colorado, to Beatrice, Nebraska
	100	24	Springfield to Pueblo, Colorado
	50	22	Hooker to Mocane and Laverne fields, Oklahoma
	24	24	Greenwood to Panhandle-Kit Carson loop
	109	20	Loop from Fourway, Texas, to Springfield, Colorado
	106	24	Loop from Springfield to Kit Carson, Colorado
	10	16	Keyes field, Oklahoma, to mainline
	6	10	Tablerock field, Wyoming, to mainline
	48.0	4–16	Additions in Mocane field, Oklahoma
	12.0	12–22	Additions in Texas Panhandle fields

Name of Company	Miles	Size	Location
El Paso Natural Gas Company El Paso, Texas	83.8	34	Loops to San Juan main line extending from San Juan County, New Mexico, to Topock, Arizona
	20.5	30	Loops to existing Permian-San Juan main line from Bluewater station to San Juan main line in McKinley County, New Mexico
	8.3	26	Loops to California main line in Yuma County, Arizona
	28.5	30	Field Transmission line in San Juan Basin, New Mexico
	78.8	18	Field line from Carson County, Texas, to Moore County, Texas
	16.0	20	Line from South Andrews field, Andrews County, Texas, to existing Goldsmith Plant
	28.1	10¾	From Nolan County, Texas, to Jameson field, Coke County, Texas
Equitable Gas Company and Subsidiaries Pittsburgh 19, Pennsylvania	6.1	16	Large to McKeesport, Pennsylvania
	17.2	16	Additions in Pennsylvania
Houston Texas Gas & Oil Company Houston, Texas	961	12–20	Baton Rouge, Louisiana, to Miami, Florida laterals
Kansas-Nebraska Natural Gas Company, Inc. Hastings, Nebraska	10	10	Grand Island to Fullerton, Nebraska
	10	8	Loop from Grand Island to Fullerton, Nebraska
	11.5	12	Replacement from Scott City to Oakley, Kansas
	1.2	6	Additions to system in Nebraska
	9	8	Lexington to Central Nebraska Public Power Electric Plant
	14	16	Replacement from North Platte to Maxwell, Nebraska
Lone Star Gas Company Dallas, Texas	3.0	16	Replacement in Tarrant County, Texas
	6.0	8	New line in Anderson County, Texas
Michigan Wisconsin Pipe Line Company Detroit, Michigan	13.6	24	Looping in Wisconsin
	10.4	24	Looping in Illinois
	471	4–24	Loops and extensions in Wisconsin and Illinois
Midwestern Gas Transmission Company Houston, Texas	1112	12–24	Main line from U. S.-Canadian border near Emerson, Manitoba — Noyes, Minnesota, to Portland, Tennessee
	648	3–18	Laterals of main line to serve communities in Minnesota, North Dakota and Wisconsin
Montana-Dakota Utilities Company Minneapolis 2, Minnesota	10	6	Cabin Creek to Texas Natural Gasoline Corporation Plant, Montana
Natural Gas Pipeline Company of America Chicago, Illinois	349	20–26	Jack and Wise counties to Fritch, Texas
	38	36	Joliet to Elgin, Illinois
	405	36	Beaver County, Oklahoma, to Joliet, Illinois (loops)
	25	—	Gathering line from Quinduna field, Roberts County, Texas, to point on existing line
	91	30	Loops in Nebraska, Kansas, Oklahoma
New York State Natural Gas Corporation Pittsburgh, Pennsylvania	27	—	Extend existing line from Elk County, Pennsylvania, to new gas field in Clearfield, Jefferson and Indiana Counties, Pennsylvania
Niagara Mohawk Power Corporation Syracuse, New York	20	Var.	Various throughout system
Northern Natural Gas Company Omaha, Nebraska	15	24	Loops on system in Nebraska
	28	24	Ogden to Redfield storage area, Iowa
	168	20	St. Paul-Minneapolis to Duluth, Minnesota and Superior, Wisconsin
	163	10–12	Main lines in South Dakota
	307	Var.	Branch lines in South Dakota, Minnesota, Iowa and Wisconsin
	100	20–24	Savannah Creek field, Alberta, to Alberta-Montana border near Cardston, Alberta
Northern Plains Natural Gas Company (subsidiary of Northern Natural Gas Company) Omaha, Nebraska	1100	26	Alberta-Montana border to Minneapolis, Minnesota
Offshore Gathering Company Houston, Texas	364	30	Offshore gas line in Gulf of Mexico from Sabine Pass to Mississippi River
Pacific Gas & Electric Company San Francisco, California	83	12–20	Glenn County to Sacramento, California
	150	34	Loops on Topack, Arizona, to Milpitas, California system
Pacific Lighting Gas Supply Company Los Angeles, California	80	30	Coles Levee to Newhall
	2.1	16–20	Potrero to Newhall
	2.8	16	Lines in East Whittier
Southern Counties Gas Company **Southern California Gas Company** Los Angeles, California	241	30	Newhall to Topock, California
Southern Natural Gas Company Birmingham, Alabama	24.0	12	New Lake Enfermer line
	2.5	10	New Lake Enfermer field line
	0.663	8	New King's Ridge field line
Tennessee Gas Transmission Co. Houston, Texas	100	—	New gathering lines in Texas and Louisiana
	557	30	Mississippi River Delta south of New Orleans to Portland, Tennessee
	120	12,20,26	Kinder, Louisiana, south 68 miles into Gulf of Mexico
	332	26	Loops in Kentucky, West Virginia, Pennsylvania
	76	24	Coudersport, Pennsylvania, to Buffalo, New York
Texas Eastern Transmission Corporation Shreveport, Louisiana	530	30	Loops from Kosciusko, Mississippi, to Uniontown, Pennsylvania
	45	24	Provident City, Texas, to McAllen-Vidor line near Blessing
	422	30	McAllen to Vidor, Texas
	141	Var.	Supply laterals from South Texas area to McAllen-Vidor line
	10	12	Loop from Broadaxe Junction to Levick Street, Philadelphia, Pennsylvania
	6	12	Loop from Broadaxe Junction to Conshohocken, Pennsylvania
	5	10	South Plainfield to Highland Park, New Jersey
Texas Gas Transmission Corporation Owensboro, Kentucky	11.37	16	Loop from Lake Arthur to Eunice, Louisiana
	11.80	10	Loop from Eunice to Elton, Louisiana
Texas-Illinois Natural Gas Pipeline Company Chicago, Illinois	59	20	Joliet to Volo, Illinois
Trans-Canada Pipe Lines, Ltd. Calgary, Alberta, Canada	1675	30–34	Winnipeg to Montreal and laterals
Trans-Carolina Pipe Line Corporation Raleigh, North Carolina	840	2–18	New line between Moore, S. Carolina and Morse, N. Carolina, with laterals

Name of Company	Miles	Size	Location
Transcontinental Gas Pipe Line Corporation	181	36	Loops on system
Houston, Texas	51	30	Loops on system
United Fuel Gas Company	7.7	12	Replacement near Ravenswood, West Virginia
Charleston, West Virginia	.8	20	Replacement in Brandykeg Section of Floyd County, Kentucky
	11.1	12	Loop line in Kentucky
	1.3	10	Additions in West Virginia
	15.6	12	Additions in West Virginia
Wilcox Trend Gathering System, Inc.	17	6	Salem field, Texas, to mainline
Cuero, Texas	6.8	3	Tidewater, Texas, to mainline

Lines Built or Underway

The following tables list details on crude, products, and gas lines built or under construction in the 12-month period ending October 1, 1956, as reported to *The Pipeline Engineer*.

CRUDE LINES

Name of Company	Miles	Size	Location	Date Completed
Arapahoe Pipe Line Company	36.0	3–8	Gathering lines on system	1956
Chicago, Illinois				
Buckeye Pipe Line Company	191	8	Reconditioning lines from Griffith, Indiana, to Lima, Ohio	1956
New York, New York				
Butte Pipe Line Company	506.7	6–16	Poplar, Montana, to Ft. Laramie - Guernsey, Wyoming	2/56
Houston, Texas				
Continental Pipe Line Company	23.78	8	Guernsey to Horsecreek, Wyoming	11/55
Ponca City, Oklahoma	7.67	6	Inman to McPherson, Kansas	9/56
Cooperative Refinery Association	8	4	Gathering lines in Oklahoma	4/56
Kansas City, Missouri	6	6	Replacment line in Phillips County, Kansas	1956
Cremona Pipe Lines, Inc.	87	8	Sundre-Westward Ho Area to Calgary	1956
Calgary, Alberta, Canada				
Gulf Refining Company	32.3	8	Citronelle to Mobile, Alabama	8/56
Houston, Texas				
The Imperial Pipe Line Company, Ltd.	10	6–8	Fairydell and Peavy producing fields to Excelsior feeder line	3/56
Toronto, Ontario, Canada				
Interprovincial Pipe Line Company	69.0	24–26	Cromer, Manitoba, to Canadian-U. S. border	8/56
Toronto, Ontario, Canada				
Interstate Oil Pipe Line Company	61.3	4–12	Additions to gathering system	1956
Shreveport, Louisiana	25	8	Bethany-Longstreet field, to Finney station, Louisiana	6/56
Kerr-McGee Oil Industries, Inc.	8	6	Cushing to Cleveland, Oklahoma	6/56
Tulsa, Oklahoma				
Lakehead Pipe Line Company, Inc.	51	26	U. S.-Canadian border to Clearbrook, Minnesota	8/56
Toronto, Ontario, Canada				
Mid-Continent Pipe Line Co.	12	4	Dillard to Fox, Oklahoma	8/56
Tulsa, Oklahoma	10	6	Norman to Washington, Oklahoma	8/56
	50	8	Osage County to Tulsa, Oklahoma	3/56
	8	6	Sasakwa to Allen, Oklahoma	1956
	21	3–8	Additions to system	1956
Montreal Pipe Line Company, Ltd.	5.6	22	Loop line near St. Cesaire, Quebec	1956
Montreal E, Quebec, Canada				
Pasotex Pipe Line Company	68	20	Loop on system from Wink to El Paso, Texas	12/55
El Paso, Texas				
Peace River Oil Pipe Line, Ltd.	106	12–16	Edson to Valleyview, Alberta	1956
Calgary, Alberta, Canada				
Powderriver Pipeline, Inc.	108	6	Sumatra to Billings and Laurel	11/55
Billings, Montana				
Salt Lake Pipe Line Company	83	10	Additions to system	12/55
Salt Lake City, Utah				
Shell Oil Company	0.24	4	Saticoy field to Union Oil Company line	7/56
Los Angeles 54, California				
Shell Pipe Line Corporation	42.8	8–10	Reconditioning line from Brookshire to Deer Park, Texas	1956
Houston, Texas	4.0	6–10	Reconditioning line in Healdton-Cushing area	1956
	55.7	3–8	Additions to gathering systems	1956
Sinclair Pipe Line Company	151	18	Jacksboro to Teague, Texas	4/56
Independence, Kansas				
Skelly Oil Company	12	6	Line replacement in Kansas	8/56
Tulsa, Oklahoma	10	6	Additional loops in Kansas	8/56
Socony Mobil Oil Company, Inc.	26.5	4–6	Gathering system additions in Central Kansas	8/56
Wichita, Kansas				
South Saskatchewan Pipe Line Company	14	8	Cantuar to Battrum, Saskatchewan	11/55
Regina, Saskatchewan, Canada	60	12	Cantuar to Dollard, Saskatchewan	9/56
Trans-Prairie Pipe Lines, Ltd.	28	3–6	Loop lines in Virden area	1956
Virden, Manitoba, Canada				
Westspur Pipe Line Company, Ltd.	109	12	Midale, Saskatchewan to Cromer, Manitoba, Canada	7/56
(Subsidiary of Imperial Oil Co., Ltd.)	58	4–10	Lines in Alida, Nottingham, Frobisher, Steelman and Midale	8/56
Toronto, Ontario, Canada	7	8	Nottingham to Alida spurline	6/56

Name of Company	Miles	Size	Location	Date Completed
Winnipeg Pipe Line Company, Ltd. (Subsidiary of Imperial Oil Co., Ltd.) Toronto, Ontario, Canada	73	10	Gretna to Winnipeg, Manitoba	1956

PRODUCTS LINES

Name of Company	Miles	Size	Location	Date Completed
Buckeye Pipe Line Company New York, New York	32	8	Mantua to Ellsworth, Ohio	1956
Cities Service Pipe Line Company	10.43	6–7	Maysville to Shell Junction in Oklahoma	5/56
Bartlesville, Oklahoma	2.84	6	Graham to Shell Junction in Oklahoma	6/56
	13.00	4	Bradley to Maysville, Oklahoma	8/56
Cosden Petroleum Corporation	103	6	Big Spring to Abilene, Texas	4/56
Big Spring, Texas	7	5	Big Spring to Webb Air Force Base	4/56
	96	8	Blanco Plant, San Juan County, New Mexico, to Wingate Plant	
El Paso Natural Gas Company El Paso, Texas	96	8	Blanco Plant, San Juan County, New Mexico, to Wingate Plant	
Gulf Refining Company	63.7	4–8	North Scurry County to Big Spring	1956
Houston, Texas	46.8	4–6	Wadell Gasoline Plant to Midland, Texas	1956
	92	4–8	Monument, New Mexico, to Midland, Texas	1956
	116	10	Lufkin to Barbers Hill, Texas	1956
Magnolia Pipe Line Company	123	8	Reconditioning line from Corsicana to DeLeon, Texas	1955
Dallas, Texas	30	8	Dollarhide to Andrews, Texas	UC
	22	4–6	Beaumont to Orange, Texas	UC
	75	8	Hull to Texas City, Texas	UC
The Ohio Oil Company	2.64	4	Distillate line in Maxie, Mississippi	4/56
Findlay, Ohio	1	8	From 10-in. product line to New Goshen, Indiana	7/56
Okan Pipeline Company Tulsa, Oklahoma	43	3	Snyder to Big Spring, Texas	7/56
Phillips Petroleum Company	5	8	Lines in Missouri	1956
Bartlesville, Oklahoma	7	12	Loop lines in Burlington, Kansas	7/56
	38	12	California, Missouri, to Paola, Kansas	1956
	17	6	Abernathy to Lubbock, Texas	1956
Plantation Pipe Line Company Atlanta, Georgia	327	18	Baton Rouge, Louisiana, to Helena, Alabama	1956
Richfield Oil Corporation	8	6	Vinvale Storage Southgate to Washington and Alameda, Los Angeles	8/55
Los Angeles, California	5.1	10–12	Watson Refinery New lines	1956
	7.4	12	Marine Terminal to Southern California	8/56
Sarnia Products Pipe Line (Imperial Oil Limited) Waterdown, Ontario, Canada	38.5	12	Loop from Waterdown to north Toronto	9/56
Shell Pipe Line Corporation Houston, Texas	10.5	4	Maysville to Healdton, Oklahoma	7/56
Inland Corporation	13	10	Fostoria to Tiffin, Ohio	11/55
(Standard Oil Company [Ohio])	34	10	Cleveland to Mogadore, Ohio	2/56
St. Louis, Missouri	5	8	Additions in Cleveland, Ohio	2/56
The Standard Oil Company (Ohio) St. Louis, Missouri	37	8	Mogadore to Girard, Ohio	1956
Southern Pacific Pipe Lines, Inc.	61.57	16	Watson to Colton, California	2/56
Los Angeles, California	356.94	12	Colton to Phoenix, Arizona	2/56
	426.79	8	El Paso, Texas, to Phoenix, Arizona	1/56
	18.12	6	Phoenix, to Luke Air Force Base, Arizona	4/56
	145.83	6	Phoenix to Davis-Monthan Air Force Base, Arizona	4/56
	14.50	6	Colton to March Air Force Base, California	4/56
Sun Pipe Line Company Philadelphia, Pennsylvania	109	14	Twin Oaks, Pennsylvania, to Newark, New Jersey	10/56
Wolverine Pipe Line Company New York, New York	3.15	16	Lines in Toledo, Ohio	10/55

GAS LINES

Name of Company	Miles	Size	Location	Date Completed
Alabama-Tennessee Natural Gas Company Florence, Alabama	21.2	12	Loop on Little Bear Creek to Alabama-Mississippi state line	1/56
American-Louisiana Pipe Line Company	1172	16–30	Cameron, Louisiana to Willow Run, Michigan	9/56
Detroit, Michigan	117	22	Bridgman, Michigan, to Defiance, Ohio	UC
Arizona Public Service Company Phoenix, Arizona	19	6	Chandler to Apache Junction, Arizona	10/56
Arkansas Louisiana Gas Company Shreveport, Louisiana	10.1	12	Additions to system in Panola County, Texas	11/55
Atlantic Seaboard Corporation Charleston, West Virginia	82	24–26	Loops in Virginia and West Virginia	1956
Canadian Montana Gas Company, Ltd. Butte, Montana	33	10	Gathering lines in Alberta, Canada	1956
Canadian Western Natural Gas Company, Ltd.	6	3	Extension to Nobleford	6/56
Calgary, Alberta, Canada	9	8	Extension to Picture Butte	6/56
	67	6–8	Nevis to Olds	1956
Central Kentucky Natural Gas Company	.7	8	Replacement in Lexington, Kentucky	7/56
Charleston, West Virginia	21	20–24	Vicinity of Cincinnati, Ohio	1956

Name of Company	Miles	Size	Location	Date Completed
Cities Service Gas Company	90	26	Blackwell, Oklahoma, to Graham, Kansas	12/55
Oklahoma City, Oklahoma	28	16	Leavenworth Kansas, to St. Joseph, Missouri	1956
	7.4	10	Valley Falls to Topeka, Kansas	6/56
	12	30	Replacement of line from Oklahoma City to Edmond, Oklahoma	1956
	17	20	Loop lines from Edmond to Cimarron River in Oklahoma	1956
	13	8–16	Replacement of line in Springfield, Missouri	1956
	6.5	6–12	Line replacement in Missouri and Kansas	1956
Colorado Interstate Gas Company	136.0	22	Denver, Colorado, to Laramie, Wyoming	12/55
Colorado Springs, Colorado	4.8	3	Ordway to Sugar City, Colorado	11/55
	1.2	8	Mainline to Laramie, Wyoming	1/56
	2.0	4	Portland to Florence, Colorado	3/56
	5.5	2	Mainline to Kit Carson, Colorado	7/56
	288.6	3–20	Gathering system additions in Kansas-Oklahoma-Texas area	1956
	239.6	22	Laramie to Green River, Wyoming	1956
	23.5	16	Morton County to mainline	10/56
	9.3	26	Loop line in Denver area	1956
	26.4	8	Mainline loop to Portland, Colorado	1956
	95.5	4–16	Gathering system additions in the Kansas-Oklahoma-Texas area	1956
Colorado-Wyoming Gas Company	18	4–16	Lines in Mesa-Thornton area	1955
Denver, Colorado				
Commonwealth Natural Gas Corporation	4	6	Chester, Virginia, to Reynolds Metals Plant	8/56
Richmond, Virginia	41	18	Loop lines west of Richmond, Virginia	1956
Consolidated Gas Utilities	3	6–8	Additions in Wichita District	1956
Oklahoma City, Oklahoma	2	4	Replacements of lines in Oklahoma	1956
El Paso Natural Gas Company	62.6	14	Jameson field to Tex-Harvey Plant, Midland County, Texas	1956
El Paso, Texas	16.2	30	Loop west of Gila Station, Maricopa County, Arizona	1956
	8.4	20	Extension from Jal No. 2 and Jal No. 3 plants to Jal No. 1 plant, New Mexico	1956
	36.3	20	Sweetie Peck plant to Goldsmith plant, Ector County, Texas	1956
	338.8	34	Loop from San Juan Basin to Topock, Arizona	UC
	150	20	San Juan mainline to Phoenix, Arizona	UC
	34	24	Ignacio, Colorado, to Blanco Plant, San Juan County, New Mexico	UC
Hope Natural Gas Company	22	12	Logan County to Wyoming County, West Virginia	1956
Clarksburg, Virginia				
Iroquois Gas Corporation	36	Var.	Gathering and delivery in New York underground storage area	UC
Buffalo, New York				
Kansas-Nebraska Natural Gas Company, Inc.	92	3–12	Lines in Colorado, Kansas, and Nebraska	1956
Hastings, Nebraska				
Kentucky West Virginia Gas Company (Equitable Gas Company subsidiary)	34.4	12	Maytown, Kentucky, to Virginia state line	4/56
Pittsburgh, Pennsylvania				
Lone Star Gas Company	108.0	6–18	Additions to system	1956
Dallas, Texas				
Michigan Consolidated Gas Company	25	12	Sparta to Muskegon, Michigan	UC
Detroit, Michigan	67	10–12	Sears to Travers City	UC
	60	10–12	Muskegon to Ludington	UC
Michigan Gas Storage Company	36	16	Zilwaukee to Mt. Pleasant, Michigan	1956
Jackson, Michigan				
Michigan Wisconsin Pipe Line Company	227.9	4–24	Additions to system	1956
Detroit, Michigan				
Montana-Dakota Utilities Company	30	16	Replacement in South Dakota	8/55
Minneapolis, Minnesota	9	6	Rapid City to Ellsworth Air Force Base, South Dakota	9/55
	4	4	Big Horn line to Signal Plant in Wyoming	9/55
	121	12	Minot to Williston, North Dakota	12/55
	28	12	Cabin Creek to Glendive, Montana	1956
	34	10	Replacement from Whitewood to Rapid City, South Dakota	9/56
	55	12	Belle Fourche to Rapid City	1956
The Montana Power Company	75	12	Deer Lodge to Missoula, Montana	6/56
Butte, Montana	44	8	Missoula to Hamilton, Montana	9/56
	75	6	Big Coulee Field to Lewistown, Montana	1956
	16.5	4	Harlowton to Heath, Montana	1956
Mountain Fuel Supply Company	31	18	Reconditioning from Evanston to Fort Bridger, Wyoming	7/56
Rock Springs, Wyoming	5	20	Loop from Granger, Wyoming	7/56
Natural Gas Pipeline Company of America	135	30	Herscher to Morris, Illinois	6/56
Chicago, Illinois	44	4–16	Miami to Kingsmill, Texas	7/56
	36	4–16	Vincinity of Rockford, Illinois	1956
Natural Gas Storage Company of Illinois	31	36	Herscher to Illinois River	1956
Chicago, Illinois				
Nevada Natural Gas Company	114	12–16	Topock, Arizona, to Whitney, Nevada	1956
Las Vegas, Nevada	42	6–12	Industrial laterals	
New York State Natural Gas Corporation	17	30	Canton to Horseheads, New York	UC
Pittsburgh, Pennsylvania				
Niagara Mohawk Power Corporation	23	10	Brookview to Hudson, New York	12/55
Syracuse, New York				
Northern Natural Gas Company	44	2–16	Permian Basin and Lea County, New Mexico	1956
Omaha, Nebraska	27.6	4–6	Hugoton field, Kansas	1956
Northern Illinois Gas Company	34	2–12	New lines in northern Illinois	1956
Bellwood, Illinois				
North Shore Gas Company	20	12	Mundelein to Deerfield, Illinois	1956
Waukegan, Illinois	6	6	Waukegan to Zion, Illinois	1956
Ohio Fuel Gas Company	65	Var.	Additions to system	UC
Columbus, Ohio				
Oklahoma Natural Gas Company	52	6–20	Additions to system in Oklahoma	1956
Tulsa, Oklahoma				

Name of Company	Miles	Size	Location	Date Completed
Pacific Gas & Electric Company San Francisco, California	150	34	Loops on big inch system	UC
Pacific Lighting Gas Supply Company Los Angeles, California	18.2	15–26	Additions to system in California	1956
Pacific Northwest Pipeline Corporation Salt Lake City, Utah	2287	6–26	San Juan Basin to Sumas, Washington, with laterals and lines in Colorado, Utah, Wyoming, Idaho, Oregon, and Washington	1956
Permian Basin Pipeline Company Omaha, Nebraska	19	16	Gathering system for 15 West Texas gas fields	1956
Phillips Petroleum Corporation Bartlesville, Oklahoma	500	2–24	Gathering lines in West Texas	9/56
	150	2–30	Gathering lines in Lindsay, Oklahoma	9/56
	2.0	4–6	Gathering lines in Brazoria County, Texas	6/56
	8.5	2–10	Gathering lines in Gray County, Texas	5/56
	5.2	2–8	Gathering lines in Hutchinson County, Texas	7/56
	21.4	2–16	Gathering lines in Roberts County, Texas	5/56
	20.0	20	Gathering lines in Pampa, Texas	4/56
	4.1	3–4	Gathering lines in Sherman County, Texas	5/56
	10.62	2–12	Additions in Gray County, Texas	1956
	57.30	2–20	Additions in Hutchinson County, Texas	1956
	2.25	4	Additions in Sherman County, Texas	1956
	14.45	2–10	Additions in Carson County, Texas	1956
Saskatchewan Power Corporation Regina, Saskatchewan, Canada	115	12	Success to Moose Jaw	1956
	57	6–8	Biggar to North Battleford	8/56
	27	6	Dana to Humboldt	8/56
	17	4	Brock Field to Eston	6/56
Signal Oil & Gas Corporation Los Angeles, California	11	2–8	Gathering system near Tioga, North Dakota	1955
South Georgia Natural Gas Company Thomasville, Georgia	104	12	Opelika, Alabama, to Albany, Georgia	12/55
	100	10	Albany, Georgia, to Ellaville, Florida	12/55
	231	2–8	Lateral lines on system	12/55
Southern Counties Gas Company Los Angeles, California	24	30	Placentia to Compton	
	31.5	30	Desert Center to Cactus City, California	1955
Southern California Gas Company—Southern Counties Gas Company Los Angeles, California	49	30	Alhambra to Newhall, California	1956
Southern California Gas Company Los Angeles, California	2.4	30	Playa del Rey to Del Rey Junction	
	1.6	16	Hollywood Station to Aliso Street Sta.	1956
Southern Natural Gas Company Birmingham, Alabama	46.9	4–30	Various on system	1956
Southern Union Gas Company Dallas, Texas	36	Var.	Additions to system	1956
Tennessee Gas Transmission Company Houston, Texas	355	4–24	Crowley, Louisiana, to Mississippi River Delta	9/56
	113.5	30	Scottsville, Louisiana, to Dinville, Kentucky	1956
	24.5	30	East and west of Morehead, Kentucky	1956
	241	26	Greenup, Kentucky, to near Mercer, Pennsylvania	1956
	250	24	Coudersport, Pennsylvania, to Greenwich, Connecticut	12/55
	370	30	Agua Dulce, Texas, to Kinder, Louisiana	12/55
Texas Eastern Transmission Corporation Shreveport, Louisiana	379	30	Beaumont, Texas, to Kosciusko, Mississippi	1/56
	29	20	Baytown to Hankamer, Texas	3/56
	29	10	Buna to Vidor, Texas	1/56
	6	8	Greenwood, Louisiana, to Waskom, Texas	12/55
	15	4–8	Muldon field to Egypt, Mississippi	2/56
	10	12	Skippack to Broadaxe Junction, Pennsylvania	1956
	1	12	Loop in Chester, Pennsylvania	1956
	19	8–10	Bethany to Longstreet, Louisiana	1956
	6	8	Longview to Greggtown, Texas	1956
	34	6–8	Aldine to Baytown, Texas	1956
	3	6	Hallsville, Texas line additions	1956
Texas Gas Transmission Corporation Owensboro, Kentucky	110	12–20	Eunice to East Lake Palourde, Louisiana	1956
	53.50	30	Partial loop from Chicot, Arkansas to Clarksdale, Mississippi	1956
	9.2	26	Loop in vicinity of Whitesville, Kentucky	6/56
	20.83	12	Petersburg to Bicknell, Indiana	1956
	3.5	2–20	Mississippi River crossing near Greenville, Mississippi	1956
Trans-Canada Pipe Lines, Ltd. Calgary, Alberta, Canada	576	34	Burstall, Saskatchewan, to Winnipeg	UC
Transcontinental Gas Pipe Line Corporation Houston, Texas	24	24	Loop of 20-in. line in South Louisiana	UC
	59	30	Loops on system	UC
	35	36	Loops on system	UC
Trunkline Gas Company Houston, Texas	23.2	26	Jackson County to Wharton County, Texas	1/56
	13.8	4–10	Additions to system in Texas and Louisiana	1956
United Fuel Gas Company Charleston, West Virginia	3.8	10	Replacement of line in Cabell County	1956
	2.9	12	Replacement of line in Kanawha County	1956
	.9	8–14	Replacement of lines in Kenova and Lexington, Kentucky	1956
	9	8	Point Pleasant to Celanese Corporation West Virginia	3/56
United Gas Pipe Line Company Shreveport, Louisiana	34	16	Baxterville to Hattiesburg, Mississippi	1956
	36	6–20	Laterals and storage field lines	1956
Washington Natural Gas Company Seattle, Washington	12.3	12	Alderwood Manor to Everett, Washington	8/56
	13.8	16	Alderwood Manor to North Seattle, Washington	8/56
	12.8	8	Issaquah to Bellevue, Washington	8/56
	8.9	16–20	Renton to Seattle, Washington	8/56
	19.7	8–16	Dieringer to Tacoma, Washington	1956
	5.8	4	Additions in Chehalis, Washington	8/56
	3.5	6	Bellevue to Kirkland, Washington	8/56
Westcoast Transmission Company, Ltd. Calgary, Alberta, Canada	670	30	Peace River area to U.S.-Canadian Border at Sumas, Wash.	UC
	823	10–26	Laterals and gathering system	UC

* * *

PACIFIC NORTHWEST PNW PIPELINE FEATURE

The Pacific Northwest Pipe

FREE ENTERPRISE BRINGS NEW ENERGY TO THE BOOMING PACIFIC NORTHWEST

Ray C. Fish
Chairman of the Board, Pacific Northwest Pipeline Corporation

NATURAL gas is opening up a new frontier in the Pacific Northwest as dramatically as the Lewis and Clark expedition opened up the territory to later thousands who were to travel the Oregon Trail. The same romance and excitement is there today as men of vision, energy, and resourcefulness are demonstrating that free enterprise and initiative build a greater America when given the opportunity.

Of greatest significance is the fact that the Pacific Northwest Pipeline, and the entire gas industry, have grown and assumed new responsibilities entirely without government loans, subsidies, or financing guarantees. Free enterprise at work has made the gas industry the sixth largest in this country, adding immeasurably to the growth and prosperity of our economy.

As the Pacific Northwest system begins full scale operation, full credit must be given to the pipe line construction forces that made the line a reality. Fish Northwest Constructors' president, R. D. Ricketts, led the team that overcame mountains, deserts, rivers, and weather to set new records for pipe line construction. The sacrifices and efforts of every man and woman connected with this great project have not gone unnoticed.

When initial market surveys were made of the Pacific Northwest in 1950, it was obvious that natural gas could fill a critical need for large supplies of cheap fuel. Competition for the right to serve that rich potential market was keen and interested firms made every effort to prove the area could be served cheaply and efficiently. From the outset, regardless of who won the battle, the people of the northwest were bound to profit.

When the stormy sessions before the Federal Power Commission were over, the best aspects of each plan contributed to the successful development of natural gas for the area. During 1957 the market will be served from fields in New Mexico and the Rocky Mountain area through nearly 1500 miles of main lines and 800 miles of laterals. Late in 1957, Canadian gas will be available through the facilities of Westcoast Transmission Company Ltd., connecting with the Pacific Northwest system at Sumas, Washington.

This unique two-way supply will provide ample volumes of cheap fuel for many years to come. With supply sources on both ends of the line and a route crossing some of the most productive and potentially productive gas

Ray C. Fish and four associates started Fish Engineering Corporation in 1946 with some $60,000 working capital. Although the young firm had some tough going with its first contracts, Fish set his sights on bigger jobs. His keen imagination and sales ability paid off and jobs came fast. Habitually short on working funds, when a new contract was signed, Fish then had to sell the bank on borrowing enough money to complete the job. Before long, he had borrowed nearly $1,000,000 and aside from the contracts, his entire assets consisted of a desk, two chairs, and a typewriter.

Since that time, Fish has handled nearly one billion dollars in contracts and has actively participated in promoting and building three large gas pipe lines (Transcontinental, Texas-Illinois, and Pacific Northwest Pipeline Corporation). He is chairman of the board of the latter company, and recently announced a $20,000,000 subsidiary line that will carry crude and products from New Mexico to Salt Lake City.

Fish grew up in Rhode Island, where his father was a commercial fisherman. After boyhood jobs in textile mills nearby, he drifted west, digging coal in Utah and working in western oil fields. He picked up two years of college at the University of Utah. In 1927 he went to work for J. A. Campbell Company, of Los Angeles, supervising the engineering and construction of gasoline and refining plants.

Three years later he joined Stearns-Roger Manufacturing Company, of Denver, where he stayed for 14 years, designing and constructing all types of oil industry plants.

When Tennessee Gas was started in 1943, touching off the great transcontinental pipe line race that would later mean great profit to his companies, Fish became vice president and director. He resigned in 1946 to form his own companies.

line Story

Initiative and aggressiveness are key ingredients in future expansion

lands in North America, Pacific Northwest has every need for expansion of industry and new populations already developing in the northwest.

Pacific Northwest is now developing nearly one-half million acres of gas reserves in the San Juan Basin and has contracted for additional supplies from other fields in Colorado and Wyoming. New reserves are constantly being discovered in the Peace River fields of Canada.

The benefits of the pipe line are not restricted to Washington and Oregon. Additional customers will be served in Idaho, Utah, and Colorado. Along the line, many exploratory wells are being drilled that would obviously unprofitable, thus assuring better utilization of our natural resources.

Canadian and American industry alike will grow with the new construction, opening up new jobs for thousands of workers. The defense and industrial development interests of both nations will be better served and the joining of the two pipe lines at the International Boundary will act as a further bond between two proven good neighbors.

Estimates of future population growth in the Pacific Northwest are highly optimistic. A recent business survey revealed that the Portland, Oregon, area, which now has a population of 600,000, will grow to 1,000,000 by 1975. A growth in energy supply must be tied in with every population growth in the United States. In this case, natural gas is leading the way, encouraging and seeking industry and investment to provide new jobs and opportunity for new populations.

An interesting fact of industrial development is the manner in which basic industry gives impetus not only to general prosperity and expansion of business, but to the creation of other new plants based on key industry. As an example, aluminum is first reduced on the Gulf Coast and then sent to the Pacific Northwest to be transposed into actual metal. At present, the aluminum bars produced there are largely shipped out of the state to other areas where natural gas is used in the manufacture of the "end use" product. It is significant that end use plants, such as extrusion and rolling mills, employ roughly five times as many people as the reduction plants. Natural gas will mean that more end use plants will be built in Washington and Oregon.

New industries in the Northwest will in many cases utilize natural resources previously undeveloped. For any area to enjoy substantial industrial development at least three basic essentials of electrical power, cold water, and a satisfactory fuel must be available. Two of these have been available for many years; natural gas is the third element that will provide the impetus for accelerated economic and industrial expansion.

Much attention has been focused on a so-called competitive battle to be waged between electricity generated by the great hydro-electric system of the region and natural gas from the Southwest. Natural gas is not, and never will be, in competition with hydro-electric power. It will be complementary to electricity. The initial volume of gas available to the area exceeds in thermal energy the total output of all the presently installed hydro-electric generating capacity in the northwestern states.

Natural gas will relieve the shortage of power and make it possible to release electricity for wheel turning energy. All industry, in establishing new plants, must be assured of ample electricity as well as other fuels. Any surplus of energy at the outset will rapidly be absorbed by new applications and industries.

The employees of Pacific Northwest Pipeline Corporation and the distribution companies of the northwest are looking forward to even greater participation in the revolutionary developments now under way. At the same time, the entire industry is aware of the serious responsibilities undertaken, and pride evidenced in a job well done is tempered by a sincere sense of humility.

PACIFIC NORTHWEST PNW PIPELINE FEATURE

There's more to modern-day pipelining than just design and construction. That's what Fish Northwest Constructors found when taking gas to a new area

Building the Best Line Possible Isn't Enough Today!

R. D. Ricketts
President, Fish Northwest Constructors

PIPELINING is typical of what makes our country grow and keeps it strong. It coordinates the resources of widely separated regions for the benefit of all. Moreover, we are able to do this through the medium of free enterprise without taking away or otherwise depreciating the rights and privileges of individuals. Not only is there no government money whatsoever in this project, but it has paid taxes since the beginning and will continue to do so.

Our industry can well take pride in the role it plays in combining the resources of one area with those of another. We transport gas from one region where it is in surplus supply to another region where it is used to supplement other resources. Both regions benefit through more employment and higher standards of living. By utilizing our resources to the fullest, greater strength and security accrues to all.

More often than not these benefits are self generating and incur additional benefits. For instance, in the case of Pacific Northwest, the primary purpose of the line was to move San Juan Basin gas from New Mexico and Colorado to the northwest states. But because the line was built, other gas fields have been discovered along the route. Such exploration and development has also resulted in the discovery of oil fields, uranium deposits, and perhaps other natural resources not reported. Conservation of natural resources? There is no better way to utilize the resources of this nation than to use them wisely and fully, linking every region. Each area can provide for the national welfare that service or resource it has in most abundance, cheaply and efficiently.

The Big Piney field of Wyoming is a typical example. Discovered some years back, gas in reserve went begging for lack of market outlet. Today, this field is the scene of widespread drilling activity, and the gas is moving to the northwest area where its energy will be used to expand alumimum and chemical production in new plants. Although it cannot be said that the plant is located in the northwest because of the availablity of natural gas from Big Piney or any other field, this cheap source of fuel did weigh heavily in the economics and design of the plant. Both of these regions are benefitting mutually from the pipe line.

Fish Engineering and Fish Northwest Constructors are proud of the roles they have undertaken in the design and construction of the Pacific Northwest Pipeline Corporation system. We were *direct agents* of Pacific Northwest Pipeline and our responsibilities were broad—extending beyond that of designing the system and letting the contracts. We were charged with the actual conception of the line and laid out the first route map in Houston, Texas, in June, 1950. We fought the bitterly contested battle for the FPC certificate and presented all testimony before the commission except that on geology and reserves.

Our work in this phase included market surveys and contracts, economics and feasibility studies, gas supply negotiations and contracts, design, engineering, mapping, selection of materials for the line, compressor stations, communications, cathodic protection, transportation, and one thousand and one other details.

We prepared a detailed estimate of cost with all supporting data as well as organization charts for the operating company. We included operating costs, procedures, accounting and billing methods — even methods to cut the red tape that was bound to tie up some operations. We worked out construction plans, specifications, and construction contracts, the receiving and letting of bids, purchasing materials, and set up an FPC code of accounting. Also our companies had the task of placing the facilities in operation plus a multitude of other operations.

As *"direct agents,"* however, Fish Northwest felt that, although all technical matters concerned in building a pipe line were overcome, yet another important job had to be taken on with equal thoughtfulness. Every Fish Northwest man engaged on the Pacific project had to be aware of the fact that he was representing "the pipe line" to millions of people in a new area.

While bringing the first high pressure gas line into the northwest, we recognized the fact that we are bringing a new and largely unfamiliar source of energy. We were highly conscious of the importance of favorable public opinion and realized that a sincere educational job had to be accomplished along with routine pipelining. **The good will of public officials and private citizens will be as important to the com-**

The Author

Richard D. Ricketts, president of Fish Northwest Constructors, has directed the construction of the Pacific Northwest system and formed the team to complete the record-breaking project.

He began in the industry with the Columbia Gas and Electric System where he participated in design, engineering, operation, and maintenance of compressor stations, gas lines, and gasoline plants for nine years. Joining Panhandle Eastern, he was a key figure in the 1936-37 expansion program carried out by the firm.

One of the original founders and a vice president of Fish Engineering Corporation, Ricketts has participated in managerial capacities in the design and construction of Transcontinental Gas Pipe Line and the Texas-Illinois line.

Wintertime construction, February 24, 1956, between Haines and North Powder, Oregon. Compressor station in the lonesome regions of western Wyoming. Elevation of the station is about 7000 ft above sea level.

pany operating the system as the Btu content of the gas they deliver. The mark left by the builders of the system will remain long after scars on the right-of-way have disappeared.

(Editor's Note: That Rickett's company accomplished its objective of good will is demonstrated by an editorial entitled "A Bon Voyage to Pipeline Workmen," which appeared in the Centralia, Washington, *Daily Chronicle* for August 3, 1956. See box, page D-40.)

The Pacific project was designed down to the "Nth" degree. With competition for the vital Federal Power Commission certificate so keen, each decision took on major proportions. The very best was demanded from every contributor to the project.

After 12 months of continuous hearings and presentation of 28,000 pages of testimony and some 650 exhibits, Pacific was finally awarded the certificate of public convenience and necessity in May, 1954. Although a long and costly procedure, the hearings retained the rights and interests of every potential gas user. In addition, it made possible the continuing operation of existing manufactured gas distribution companies on a profitable basis.

Working for the FPC certificate, we were constantly aware of our other more intangible responsibilities. **In the pipe line industry, it is no longer good enough to build the best line possible. We must perform this public service in such a way that not one citizen is deprived of his basic rights and freedoms.**

From FPC authority, the emphasis moved to financing of the project. Surveys, studies, and plans were again subjected to detailed scrutiny by new experts. When financing was completed on May 6, 1955, Fish Northwest had 11 people on the payroll. Within 110 days, 111 miles of pipe line was in the ground. Prior planning had set up an organization that would employ almost 2000 people in the Fish companies and direct the activities of thousands of contractor personnel.

As the first length of pipe was laid on July 8, 1955, acquisition of right-of-way was well under way, materials were on the way, and many contracts let. The job — 1487 miles of main line, a total system of 2571 miles. An enterprise that would consume one-half million dollars every day was under way.

Much has been said about the terrain spanned by this line — and admittedly, it is as rugged as that of any line in this country. Yet, through tedious study and re-routing during preliminary stages, the distances of extremely difficult passages were held to a minimum. For instance, there are only five miles or so of rough terrain crossed by the line in the Green Mountain area. And in the Cascade Range, most of the extremely difficult pipelining is limited to a 50-mile stretch.

Needless to say, the minimizing of difficult terrain saved money and time in construction. Much of the credit for this goes to the airplane, which is the most useful tool in the modern-day pipeliner's stable. The effectiveness of pipe line location work from suitable aircraft, bearing experienced pipeliners, was proved twice before for our company. This was the method we used in locating the route of Transcontinental Gas and Texas-Illinois lines.

In order to connect with market outlets in time to supply gas for the 1956-57 heating season, construction had to proceed during the 1955-56 winter. In the areas of southern Idaho, western Wyoming, and eastern Oregon, winters are always severe. Our long range weather forecast service predicted unusually severe conditions ahead with abnormally low temperatures. We decided in favor of continuous construction during this winter after careful planning and cost analysis.

Our weather predictions were accurate and we met the most severe winter in 52 years. In spite of snow up to 20 ft deep, temperatures as low as 40F below zero, and frost lines 8 ft deep in some areas, contractors were successful in laying about 150 miles of main line during the months of January and February. The average for all contractors working was 3250 ft per calendar day. Compressor station work continued through the winter, too, giving us six compressor stations ready for operation in the early spring. All of this work is a tribute to the ingenuity and planning of the contractors and men on these jobs.

I would be remiss not to mention other phases of the projects. Without the remarkable performance of our land department under the direction of J. Don Creveling, who is a veteran of 30 years in the acquisition of right-of-way, our work often would have been at a standstill. The difficulties he overcame were great—stemming primarily from the widely varying (and frequently, little used) state statutes and procedures concerning eminent domain. Also, there were deliberate attempts by groups representing competitive fuels to delay and increase the cost of the line. Such harassment achieved but little success for its authors — and then only because there was insufficient time to refute thoroughly the many false statements.

As the direct agent for the first large gas transmission system in several states, it was necessary for us to counsel, advise, and, in some instances, testify for commissions, agencies, etc., regarding safe design practices. Although this line was completely designed under the ASA code, the State of Washington found it advisable to adopt even more stringent requirements. This necessitated many changes in our designs, purchasing, and contracts on the 920 miles of construction in that state.

As it was also our responsibility to set up an operating organization, it was a real personal pleasure to be able to reward at least a small portion of the men who participated in building the line by transferring them to the new company. Of course, Pacific Northwest profited in obtaining highly qualified experienced personnel.

I do not feel that you simply *build* or *promote* a pipe line such as this one. You live it and breathe it as well. This was as true of each individual Fish employee as myself. The line is *their* accomplishment.

PACIFIC NORTHWEST PNW PIPELINE FEATURE

New completion methods and aggressive drilling program have increased well potentials and extended limits of San Juan Basin

San Juan Basin Gassers Ready to Deliver

J. M. Clark
Vice President,
Pacific Northwest Pipeline Corporation

RESERVES and deliverability play a large part in completing the pipe line picture. During the initial stages of any major pipe line, estimates of performance and geological studies are subjected to the closest scrutiny. Even the most conservative figures are usually pared again to make sure that enthusiasm for the work at hand has not prompted too optimistic predictions.

The San Juan Basin in northwestern New Mexico and southwestern Colorado has long been highly regarded by geologists and operators as a major gas reservoir. Development drilling over the years indicated that the basin was even larger than originally believed, and the ratio of dry holes was very low. Deliverability sometimes posed economical problems, however.

When Pacific Northwest began to organize acreage with an eye toward the rich northwest gas market, drilling activity in the basin was at an all time high. Pipe line expansions had kept operators busy meeting the demand. This increase in demand was directly responsible for discoveries and developments in completion techniques. At the same time, drilling costs were going down and wells were being brought in faster. After careful study and planning, aided immeasurably by the experiences of others in the area, the go-ahead was given to establish 20-year reserves for a line that would deliver 345,000,000 cu ft of gas a day. It turned out to be a sizeable order. Since operations began 16 months ago, however, Pacific's development program has indicated that reserves estimates as established on certification were conservative.

When Pacific completed its original financing on May 4, 1954, it held oil and gas leases on proved and semi-proved acreage in the San Juan Basin appraised by Brokaw, Dixon and McKee, independent consulting geologists, as having approximately 2.34 trillion cu ft of gas reserves. Most of the gas required for the operation of the system during the first year will come from the 460,000 acres under lease by Pacific.

Since the original estimates, development of Pacific's acreage and extension and development of other areas of the basin by independent producers indicate that the volume of gas ultimately recoverable will be greatly increased.

Pacific has also contracted to buy additional supplies along the route of the line. Now under purchase contract is approximately ½ trillion cu ft in fields along the route in Colorado, Utah, and Wyoming. In 1957, when Canadian gas is tied in with the system, reserves totaling 3.5 trillion cu ft will back up Pacific's ability to serve the market.

In addition to its own reserves, Pacific has purchased and expects to be able to purchase large additional volumes of gas from other operators in the basin and elsewhere, bringing total reserves available to approximately 8 trillion cu ft.

During the first year of operation, Pacific expects to deliver a maximum of 393,000,000 cu ft a day. After Canadian gas is tied in, an estimated 696,000,000 cu ft a day will move through the line. If Federal Power Commission applications now filed or pending are certificated, Pacific's market will exceed 800,000,000 cu ft of gas per day by 1958.

Construction of the line has spurred oil and gas exploration in potentially productive areas all along the route. Experience indicates that more gas will be developed and available for market in the Paradox and Uintah Basins of Colorado and Utah and in the Green River and Red Desert Basins of Wyoming.

Pacific's production department had to be ready to go immediately after financing was completed. From offices in Albuquerque, New Mexico, a nucleus of key people had the program underway in record time. Because distance is such a large factor in the area, key personnel would sometimes be together only once a week for a regular operating committee meeting. Flying in from all parts of the basin and Rocky Mountains would be R. N. Richey, manager, land department; Val R. Reese, manager, geology section; W. R. Johnston, manager, production operations, and usually a number of geologists, accountants, and reservoir engineers with last-minute information on the progress of the program. Pacific Northwest was in the production business in a big way.

Results of the drilling program have been exceptional. Potentials of wells completed today in the San Juan Basin run about twice the potentials of comparable wells completed in the past. Although steel costs are greater, well costs are no higher because water rather than oil is being used as a fracturing medium, time is saved on the hole with new completion methods, and

The Author

J. M. Clark, vice president in charge of production, Pacific Northwest Pipeline has nearly one-half million acres in which to ply his specialty. Formerly general drilling superintendent for The Chicago Corporation, Clark directs the program that has 250 wells ready to tie into the line by the end of 1956. He is also vice president of Northwest Production Corporation, production subsidiary of Pacific Northwest.

more of the hole is drilled with gas.

Recently a well in the basin producing from the Mesaverde formation at 5500 ft, was potentialed at 43,000,000 cu ft a day, making it Pacific's biggest. Much of the credit should be given to new completion methods. Average potential for Pacific wells completed since May, 1955, is 8,000,000 cu ft a day. Basin average for wells completed with older practices is only 3,500,000 cu ft. At the present time it is impossible to say whether new methods will make the wells produce more gas during the lifetime of the field. Of great importance to the Pacific line is that gas will be produced quicker and therefore cheaper.

By the end of 1956, Pacific will have acquired by purchase and by drilling a total of approximately 250 net wells. Long range plans call for a total of about 1000 wells to be drilled over a 10-year period at a total cost of about $65,000,000.

Production-wise, Pacific is ready to serve the markets of the Pacific Northwest. The reserves that have been patiently waiting for millions of years are finally being put to good use.

PACIFIC NORTHWEST PIPELINE PNW FEATURE

Seldom has pipelining been more difficult—and more colorful

Construction Problems In the Mountains

James W. Hall
Project Manager,
Fish Northwest Constructors, Inc.

THE best way to overcome difficulties in pipe line construction is to avoid them in the first place. This was especially true of the Pacific Northwest system. The terrain between any known gas supply source and the Pacific Northwest states is so rugged that the feasibility of laying such a line was questioned for years. For this reason the very first and perhaps the most important step in the construction of a line from the San Juan Basin to Washington and Oregon was to select a route that avoided the greatest number of obstacles.

This task took many months, many airplane miles, and many weary miles on the ground. But the route selected actually avoids all but a fraction of the great obstacles.

Line Location

The line has been dubbed by many as the "Scenic Inch," and there is considerable justification for this name. It traverses America's most colorful and beautiful (and sometimes wildest) areas. From its initial point near Durango in southwestern Colorado at the junction of a network of gathering lines lacing the San Juan field, the route, as located runs northwest, skirting the famous Mesa Verde and following the Mancos Valley to Dove Creek, Colorado. From there it passes over the sandstone formations near Monticello, Utah, that give the first hint of the fabulous carvings of the Colorado River to come. It crosses this river near Moab, Utah, and sweeps upward along the base of the great escarpment that for ages has held the Colorado in its course. It traverses desert wastes marked only by silent redstone monuments carved by endless winds and

The Author

JAMES W. HALL, project manager for Fish Northwest, held almost every kind of field job before entering the pipe line construction business for himself. His training included research on tank welding and specialty layout and fabrication of structural steel and sheet metal items.

Hall joined Fish Constructors, Inc., in 1948 and was superintendent of construction for Transco project. He became Transco's pipe line superintendent until he went with Fish Northwest for the Pacific project.

Editor's Note: When R. D. Ricketts discussed this series with The Pipeline Engineer, he stated, "I am particularly anxious that my first assistant, Bill Hall, be given credit for his major contribution to the smoothness and efficiency that this project has known. I have relied in utmost confidence on his very excellent judgment and the many important decisions he has made. He has been more than a right hand . . ."

The Scenic Inch

Crossing some of the most rugged and spectacular terrain in North America, Pacific Northwest Pipeline can aptly be called the "Scenic Inch." From the time the 26-in. line leaves the gasoline plant at Ignacio, Colorado, until reaching Green River, Wyoming, it snakes through tourist country all the way. The 22-in. line in the middle of the system follows the route of the Oregon trail, even the modern pipeliner could not better the trail blazed years ago. After crossing the Columbia River at Umatilla, Oregon, 26-in. follows the famous Columbia River Gorge, then turns north at Portland to tie in Seattle and Tacoma.

In all, 1487 miles of main line make up the system. Sales and supply laterals and gathering systems bring the total to 2571 miles.

After Canadian gas is available in 1957, gas will come southward across the International Boundary; fields in Wyoming, Colorado, and Utah will feed into the middle of the line; and the San Juan Basin in New Mexico will start gas northward. All three sources will supply the markets of the northwest and the intermountain area. This unique supply will assure uninterrupted service anywhere along the line.

During the first year, Pacific will deliver 393,000,000 cu ft of gas on a maximum day. After the Canadian tie in, some 696,000,000 cu ft can reach the markets every day.

The Pacific line is not only scenic — it's busy.

Construction along the Columbia River Gorge. The right-of-way was cut into mountain side. The trees are about 175 ft high.

Across the barren wastes where dust along the churned up right-of-way was one of the difficulties. Lack of roads added to the logistic problem.

turns back into Colorado and heads northward to climb over Douglas Pass and down into the White River Basin near Rangely, Colorado.

Next come the Uinta Mountains in which are found remains of ice age dinosaurs (now preserved in Dinosaur National Park). The line crosses the Green River near Jensen, Utah, and emerges from the Uintas for a second crossing of the Green River near the site of Flaming Gorge Dam, which the government will build as a part of the upper Colorado flood and power project.

From here, the line turns northwest across Wyoming grazing lands, where it again encounters the Green River in its meanderings; then northwestward to Kemmerer, Wyoming. The line runs into the valley of Bear River near Montpelier, Idaho.

Following meanderings of the valleys and streams, the route crosses foothills west of Soda Springs, Idaho, and joins the valley of the Port Neuf River and follows it to Pocatello, Idaho. Then it runs through the lush farms of the Snake River Valley to Ontario, Oregon, where it strikes northwest through the Blue Mountains, so-named because of the ever-present blue aura reflected from the giant firs and spruce. The line drops into the Columbia River Valley near Pendleton, Oregon, crosses the Columbia at Umatilla and turns westward toward the Cascades. Skirting along the Columbia where it cuts through the Cascade Range, the line encounters crags like those of the Rockies.

The route emerges onto the coastal plain near Vancouver, Washington, turns north through timber lands and rich farms, past Tacoma, Seattle, and Bellingham, to a point on the Canadian border near Sumas — its final destination.

Back at the Columbia River crossing near Umatilla, one branch of the main line turns northeast toward Spokane across the wide expanse of wheat lands of eastern Oregon. At the Columbia River crossing, a third line strikes north to intercept the Yakima Valley and follows it to Ellensburg where it crosses the mountains to drop back into the Columbia River Valley at Wenatchee.

Contracting the Work

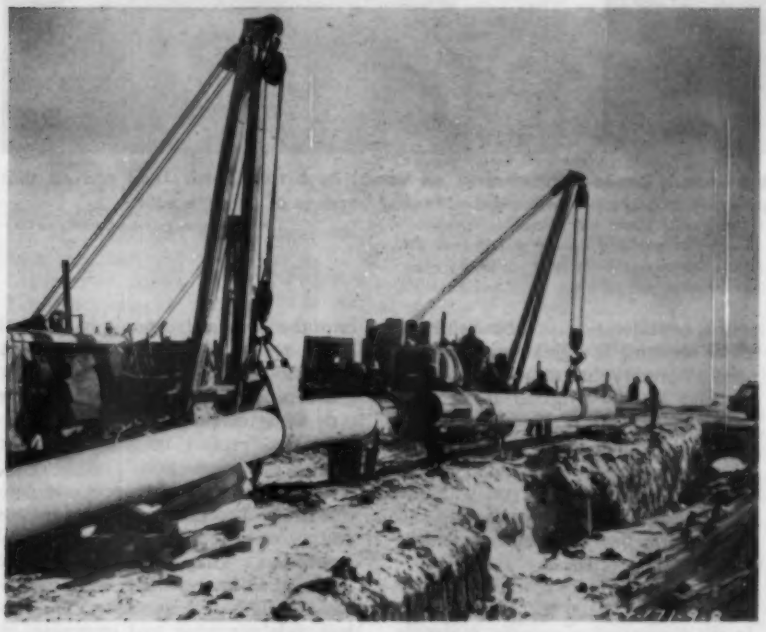
Despite the time and effort expended in locating the route with fewest obstacles, there remained many obstacles of sufficient magnitude to challenge the best efforts of pipeliners. **In order to minimize the effects of difficult terrain, the work was divided insofar as possible into sections that had the same characteristics throughout their length. Extremely difficult mountainous terrain was let in short sections; sections through the forests were let separately from sections through the rolling foothills. This worked well for the contractors and company as well. Each section of line presented specific problems to be solved by the contractor engaged on that particular section.**

This enabled the contractor to equip and organize his spread or spreads for a specific type of work and presumably increased his chances of making a fair profit.

Logistics

In all areas, logistics was a problem on par with the physical obstacles offered by the terrain. The great distances between town and shipping points, and lack of roads made it essential that all operations be planned and executed to avoid any back-tracking

Construction during winter finds ditch filled with ice and water. Temperature sometimes fell 20 degrees below zero. *Photo courtesy Fulghum Contracting Corp.*



Winter pipelining north of Baker, Oregon. *Photo courtesy Caterpillar Tractor Co.*

with men or material. **Shipping points were carefully selected to attain the most favorable balance between rail and highway hauls.**

To expedite his construction operations, the contractor became a road builder, constructing access roads into isolated areas. These roads assumed a semi-public status and will continue to serve in the operation of the line.

To provide as much lead time as possible between operations, each construction spread was permitted to proceed as rapidly as possible, without regard to progress of subsequent operations. In some sections, construction operations were spread out as much as 50 miles. Such widespread activities created additional problems of management and control, but paid off in large measure by more economical and rapid progress.

Canyon and Steep Slope Construction

In traversing mountainous country, the route took advantage of terrain to avoid slide areas. In order to do this, the line had to be routed up some steep slopes and through deep canyons.

These high slopes and deep canyons created problems that could be solved only by brute force. Right-of-way and ditch had to be carved into the mountain sides, and pipe, material, and equipment had to be carried there for installation. Whole mountain sides were sometimes blasted away to make right-of-way for the line. Often, the slopes were so steep that men had to be anchored by ropes to enable them to work on the mountain sides.

Some of the deep and narrow canyons were spanned; others could be crossed only by laying the pipe down the slopes and across the bottom.

On such slopes, the line was firmly anchored by means best suited for the individual case. In some cases, simple bends in the line as it descended the slopes provided sufficient anchorage. Sometimes, concrete blocks were cast into the rock in the sides of the canyon to provide anchorage for the pipe; whereas in other instances, anchor pins driven directly into the rock formation were sufficient. By whatever means, when the pipe was anchored, backfill was placed and held in place by breakers of sack or concrete.

Where equipment could not pull its own weight up the sharp slopes, it was assisted by winch lines, attached to tow tractors located at strategic points or by permanent winches set at the top of the slopes, where they remained throughout operations. Ever present was the danger of equipment running wild down the mountain slopes — a danger to be avoided only by constant vigilance on the part of the operator.

Forest Construction

In the heavily forested areas, felling of enormous trees was only the first step of a major problem. Brush and slash from a single tree created large quantities of debris, choking the en-

Prime Contractors on Pacific Northwest Project

Midwestern Constructors, Inc.— 79.14 miles of 26-in.; 90.79 miles of 22-in.

River Construction Corp. — 213.95 miles of 26-in.

Montin-Benson Corp. & G. G. Griffis, Inc. — Cape Construction Co., Inc. — 83.54 miles of 26-in.

Cape Construction Co., Inc. — 57.11 miles of 26-in.

Fulghum Contracting Corp. — 93.41 miles of 22-in.

A. P. V. Company, Inc. — 81.46 miles of 26-in.

Engineers Limited Pipeline Co. — 55.52 miles of 26-in.

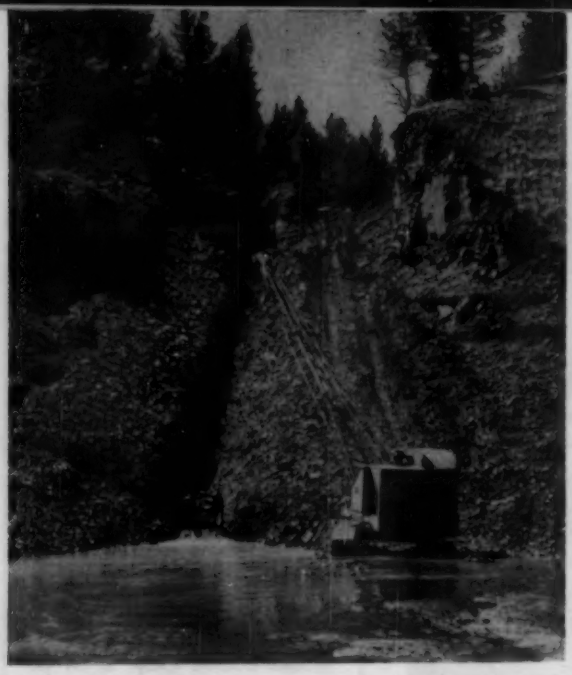
Curtis Construction Co., Inc. — 80.91 miles of 22-in.

Montin-Benson Corp. & G. G. Griffis, Inc.—Curtis Construction Co., Inc. — 91.83 miles of 22-in.

H. B. Zachry Co. — 217.40 miles of 22-in.

R. H. Fulton & Co. — 167.31 miles of 26-in.

Associated Pipe Line Contractors, Inc. — 72.75 miles of 26-in.



In the Blue Mountains the line crosses the Grande Ronde River. The dragline up the slope is being held in place by two tractor winch lines.

Pipelining as usual in bitter cold. Tests proved that welds did not suffer because of extreme cold.

Photo courtesy Fulghum Contracting Corp.

tire width of the right-of-way. The trunks of trees, when cut into timber logs, added to the barrier, which had to be removed before other operations could follow. Logs were hauled to sawmills, where they were cut into commercial lumber. The slash and brush were burned on the right-of-way under close supervision of various fire control authorities.

Deep snow and heavy rain made a quagmire of the mountain meadows and valleys, adding to the work.

Desert Construction

While offering welcome relief from the high mountains, the desert areas traversed by the line presented difficulties to test the ingenuity of the pipeliner and durability of the equipment. Under the beating of heavy equipment, the fields turned into a churning, choking powder that covered men and equipment in a smothering cloud. The men, as ever adaptable, took the heat and dirt in their stride. The fine dust did its worst in the gears and bearings of the equipment, cutting like emery and requiring constant and expert maintenance.

Water

In all of the country traversed, water is a precious commodity and is guarded jealously by one and all. In years past, small wars have been fought by inhabitants of these areas over the rights and use of water. Although the impulse to physical violence has abated, extreme consideration of the value of water remains, and great care must be used to preserve its sources and flow. Through heavily irrigated areas, such as the Snake River Valley, flow of irrigation water had to be maintained at all times. Special crews, assigned to certain areas, were charged with the specific responsibility of patroling and maintaining flow of water in canals and irrigation ditches.

Restoration and maintenance of right-of-way created special problems. In the mountainous country, measures to prevent washes and erosion from the melting snow and heavy rain were equal to the requirement to combat erosion by wind in the lower desert country. In the flatlands of the arid areas, spreading and disking of straw into the soil, soil separation so that heavy topsoil would be placed back over the right-of-way, numerous sack breakers, and countless terraces, were only some of the devices used to restore and protect the line after the passing of construction.

At all times, the engineers and contractors had to maintain conscientious and coordinated activities with local enterprises. Tulip growing, potato farming, culture of hops, orchard husbandry, timber conservation, fire control, fish migration and spawning, irrigation and water conservation, mink breeding, were a few of the activities with which the pipeliners were required to become familiar and coordinate their work to avoid undue damage and public resentment.

A "Bon Voyage" to Pipe Line Workmen

As actual construction on the main line of the big natural gas distribution system approaches completion in this area, the citizens of the Twin Cities look with regret upon the departure from this community of the men who have been engaged in this work. All of us have enjoyed meeting and talking with these people and have appreciated the friendly manner in which they have done business here.

We have heard many stories about Texans and Texas but rarely have been given an opportunity to meet so many of them at once. They are a happy and humorous lot. We have tended to depreciate all stories about these wonderful people. The unfavorable ones we will continue to depreciate but those which look with favor upon Texans we will regard as most likely being true.

Within a few weeks when natural gas begins to flow through this big pipe line, we will have a constant and living memorial to the men who built the line. It will continue to bring to our memory the wonderful summer of 1956 when Texans came to Lewis County, performed their work vigorously, enjoyed life and left with such a favorable impression. Good luck to you wherever you go, and we hope you will have as many happy memories of us as we have of you.—From Centralia, Washington, *Daily Chronicle*.

PACIFIC NORTHWEST PNW PIPELINE FEATURE

The fire hazard was great — but the fire prevention program was successful

Fire Prevention Practices Through the Forests

Eldon H. Myrick
Supervisor of Fire Prevention, Fish Northwest Constructors

FROM the standpoint of destruction of natural resources and wealth, few catastrophies rival a forest fire. The devastation and great energy release can be appreciated only by those who have seen one.

For this reason, Fish Northwest Constructors made every effort to prevent fires as they cleared the right-of-way and laid a line through some of the most valuable and **most flammable** forests in the world. Their approach to the problem was sensible; moreover, it was successful.

Protection officials throughout all areas were advised of construction plans and with their help Fish Northwest worked out a fire prevention program. The contractors were instructed along these lines and all of them followed the program.

Here is a brief summary of most of the rules followed in the State of Washington, which is typical of other states:

The Author

ELDON H. MYRICK, supervisor of fire prevention, Fish Northwest Constructors, is a veteran of 38 years with the U. S. Forest Service. Myrick has been active in many forestry positions throughout the Pacific Northwest area. He retired as forest supervisor of Region 1 (Lolo National Forest, Montana) in 1950. Since that time he has acted in several forestry consulting capacities. He joined Fish Northwest in July, 1955, and has directed the program of timber utilization and fire prevention along the Pacific Northwest route.

1. Contact the local fire warden or district ranger before start of operation.

2. The closed season within which burning of slash is prohibited except under permit from a warden or ranger, is from March 15 to October 15, inclusive, in western Washington. Secure a permit from the local warden or ranger before burning any slash. No fires are to be left unattended at any time.

The following requirements must be complied with when operating upon any lands within a protective district, or within one-eighth mile of any forest land during the closed season.

3. All operations can be closed and burning permits cancelled at any time by the warden or ranger during periods of extreme fire hazard.

4. During the closed season no fires of any nature may be set in any county within which a warden or ranger is located without first obtaining a permit.

5. Permit to operate power-driven machinery within a protective district is required.

6. Every conveyance operated through forest, brush, range, or grain areas shall be equipped in each compartment with ash trays for the disposition of cigarettes, cigars, matches, etc.

7. No one may throw away any lighted tobacco or matches, etc. during the closed season.

8. No one may smoke when walking or traveling to or from the job in areas of fire hazard except on paved or surfaced roads. This also applies to equipment operators, etc.

9. Notices pertaining to smoking rules must be posted in a conspicuous place in conveyances hauling personnel to and from work.

10. Watchman capable and trained in fire fighting and handling equipment will be required when spark-emitting or electrical engines are operated within one-eighth mile of forest lands during the closed season. Watchman must be kept at scene of operation for a minimum of two hours after operation has ceased.

11. Before operating any merchantable timber area, a timber cutting permit must be obtained.

12. No blasting fuse may be used for the period from June 15 to October 15 without first obtaining a permit from the local district warden's office.

13. The local district warden may require a 500 gal or larger tank and power pump and 500 ft of 1-in. hose, mounted as a mobile unit that will be available as fire mop-up equipment.

14. All exposed snags of 15 ft or more in height within 150 ft of burning must be felled.

15. It shall be unlawful to operate any spark-emitting engine within one-eighth mile of any forest land during the closed season unless the following tools are provided: One sealed tool box each with the clearing crew and welding crew, each to contain the following tools: 3 D.B. axes having heads weighing not less than 3 lb and not less than 32-in. handles, 6 L.H., round pointed shovels or "D" handle round pointed shovels and 6 adze eye forestry fire-fighting hoes.

To be kept adjacent to the tool box, one power chainsaw in working condition during period of actual operation and until the end of watchman service, and one 5-gal back-pack pump can filled with water and 100 gal of water.

Tool boxes must have water-proof lids, be of sound construction and be provided with hinges and hasp so arranged that the box can be sealed properly by the warden.

16. All gasoline, diesel, and electric skidding or loading engines must be equipped with two chemical fire extinguishers of not less than 1½-qt capacity each and exhaust turned up perpendicular or equipped with a spark arrester.

17. All tractors must be equipped with one chemical fire extinguisher of 1-qt capacity and exhaust turned up perpendicular or equipped with a spark arrester.

18. All trucks must be equipped with a 1-qt chemical fire extinguisher and equipped with 1 D.B. axe, 1 R.P. shovel and provided with adequate muffler or spark arrester or the exhaust turned up perpendicular.

19. Standby crew must be available on weekends and holidays, providing any burning is done. The local district fire warden's offices should have telephone numbers of foremen, equipment operators, etc.

20. Power saw operators must keep in their personal possession a chemical fire extinguisher of at least 8-oz capacity or a suitable shovel, and the power saw equipped with a muffler or other device to prevent emission of sparks.

21. Contractors must keep in daily touch with local district headquarters on weather conditions during fire season.

PACIFIC NORTHWEST PIPELINE PNW FEATURE

The heavy 0.812-in. wall, 20-in. pipe is lowered into the water of one of the swiftest crossings in the world — the Columbia River just below the McNary Dam.

All were submerged crossings; the Columbia was the toughest

Design and Construction Of the River Crossings

K. C. Biedermann

Superintendent of Construction, Fish Northwest Constructors, Inc.

THE design and construction of the river crossings on the Pacific Northwest Pipeline system was folded into the design and construction of the project as a whole.

After the general location of the overall pipe line had been selected, each river to be crossed was investigated as to its characteristics, and alternate locations of crossings checked. Upon final selection from these alternates, the decision as to the installation of a single or double line crossing was made on the basis of characteristics of the river at the point of crossing, the geographical remoteness of the site, and the probability of future development of the river in relation to the crossing.

The studies resulted in a decision to install multiple-line crossings on the Colorado River at Moab, Utah; three crossings on the Green River between Jenson, Utah, and Green River, Wyoming; two crossings on the Snake River, one at Glenns Ferry, the second at Payette, Idaho; and two crossings on the Columbia River, one at Umatilla, Oregon, and one at Vancouver, Washington.

The wall thickness of pipe to be used was predicated on obtaining as much of the necessary negative buoyancy in the steel as possible in relation to the wall thickness of pipe available in time for the construction schedule. The positioning of the pipe in each individual river crossing was arrived at from the studies, which indicated that 10 ft below the normal beds of rivers made up of sand and/or gravel and 1-ft cover in rivers whose beds were solid rock would provide safe and dependable crossings that would not be affected by the vagrancies of the stream.

The most difficult crossing on the project was the crossing of the Columbia River between Oregon and Washington, known as the Umatilla Crossing. The flow of water at point of crossing is extremely rapid, lying just below the spillway of McNary Dam, approximately 5 miles upstream from the pipe line.

The bed of the river is made up of boulders — some as large as ordinary houses — and sand overlain with solid rock strata that vary considerably in elevations across the river.

The main channel of the river is 24 ft below mean low water and is 1000 ft wide. The width from water edge to water edge is 3000 ft. The Oregon side of the river crossing is dotted with rock "hay stacks," several of which ex-

The Author

K. C. Biedermann rejoined the Fish companies in the spring of 1955 as construction superintendent. Just prior to this he was with River Construction Corporation, and was superintendent on the United Gas Pipe Line expansion project for Brown and Root from 1951 to 1953. He attended the University of Michigan, worked for consulting engineering firms in Ann Arbor, Michigan, and entered the pipe line industry when he went to work for Panhandle Eastern Pipe Line Company in 1941. In 1949 he resigned to become division superintendent for Fish Constructors on the Transcontinental Gas Pipe Line project.

tend over the surface of the river in low water and are made up of large boulders that have been brought down the river by the fast water and accumulated through the ages to the present formations.

The crossing was designed for the installation of the pipe into solid rock where such formations exist at the higher elevations and well into the overburden of other areas, resulting in a normally flat crossing for a distance of 3200 ft. The construction of the first line of the crossing was begun in November, 1955, and was completed in April, 1956. Construction of the second line began in August, 1956, and should be completed by January 1, 1957.

The lines are 20 in. OD by 0.812 wt pipe weighing 167 lb per linear ft, giving a negative buoyancy of 25 lb per ft.

Large derrick barge helps as the pipe goes across the Columbia. The current varied from 7 mph up.

PACIFIC NORTHWEST PIPELINE PNW FEATURE

ASA and State of Washington codes were construction criterion

Design of System

Arthur B. Allyne

Vice President of Operations, Pacific Northwest Pipeline Corporation

ALL facilities of the Pacific Northwest System have been designed in strict accordance with the industry code, "Gas Transmission & Distribution Piping System," the so-called Section 8 of the American Standard Code for Pressure Piping (ASA B31.1-1955) as sponsored by the American Society of Mechanical Engineers. This code was the construction criterion for the system throughout the states of New Mexico, Utah, Colorado, Wyoming, Idaho, and Oregon. In the State of Washington we were faced with additional requirements brought about by the issuance of a special code enacted after start of construction by the Washington Public Service Commission.

The mainline system and all sales laterals were planned in accordance with the provisions of the ASA Code for a designed operating pressure of 800 psig. In the case of the 26-in. mainline pipe this meant the use of 0.281-in. wall in Class 1 areas, 0.344-in. in Class 2 areas, 0.406-in. in Class 3 areas, and 0.500-in. in Class 4 areas. All mainline pipe and the larger sales laterals throughout the system were electric-resistance weld pipe of 5 LX-52 quality.

All pipe utilized throughout the system received mill inspection under the supervision of independent mill inspectors as well as mill hydrostatic tests. In addition in the case of the mainline pipe a random length was taken from each 40 miles of production and burst tested to destruction for a further check of pipe quality. In no case did a burst test give results lower than those which the specification of the pipe indicated.

Mainline pipe as well as some of the sales lateral pipe was produced at the Provo, Utah, plant of the Consolidated Western Steel Corporation and the Napa, California, plant of the Kaiser Steel Corporation. Other quantities of pipe were obtained from Republic Steel, Lone Star Steel, A. O. Smith Corporation and National Tube among others.

Two independent X-ray companies were retained to provide X-ray services throughout our system. All of our 10-in. diameter and over was X-rayed with a minimum of 20 per cent of the field welds being so tested. In the State of Washington all pipe was X-rayed regardless of size. Due to the sparse terrain through which most of the line traverses and the selection of the route by our field engineers only a few miles of other than Class 1 areas were encountered until the State of Washington was reached.

With respect to road, highway and railroad crossings in most cases we exceeded the requirements of ASA Code. For example, in Class 1 areas when passing under highways, public streets and railroads the ASA Code permits Type A construction with casing or Type B construction without casing. In our construction we installed both Type B construction pipe and casing.

Also in the case of unimproved public roads that receive heavy traffic—which is frequently encountered in western areas — or where it appeared such unimproved roads might be hard-surfaced in the future, we employed Type B construction as well as casing in Class 1 areas. The same philosophy was followed in Class 2 and Class 3 areas.

In all of the compressor stations throughout the system all piping has been installed in accordance with the Type C construction requirements of the ASA Code. In other words in the case of 26-in. piping areas, the mainline outside of the compressor station was 26-in. x 0.281-in. wall; whereas 26-in. x .500-in. wall pipe was installed within station yard boundaries.

Upon completion of construction all of the pipe installed on the Pacific North west System was proof-tested with gas, air or water in accordance with the requirements of the ASA Code and depending upon the class of area in which it was located. These procedures are described elsewhere.

Washington Code

Upon entering the State of Washington we were confronted long after construction was started in other sections of the system (and all of our pipe requirements for 1955-1956 had been committed,) with the severe provisions of the so-called Safety Code promulgated by the Washington Public Service Commission. While the Washington Commission adopted the ASA Code as a starter, their code imposed additional requirements under certain conditions which necessitated on short notice the acquisition of thousands of tons of heavy-wall pipe. Due to the much greater density of the population in the State of Washington and the mountainous terrain which covers most of the state, it was found most difficult to either relocate our lines on the one hand or to provide the heavy-wall pipe required on the other.

Two rules in the Washington Code provided us with our most difficult problems. Rule 2 provides that in the case of lines operated in excess of 500 psi they should not be constructed with less than Type C construction where such lines are within 500 ft of an individual place of residence, property which has been zoned as residential, a building used for public gatherings, any school, hospital, public building, playground, building devoted to business employing more than three people or any public highway.

Rule 3 provided that in the case of any line operated in excess of 250 psi it should not be installed within 100 ft of any building intended for human occupancy under any condition, unless authorized and approved by the commission. It will be noted that these rules apply to individual dwellings and ignore the usual population density indices established under the ASA Code.

In the case of Rule 2, while Type B construction was given no consideration, some relief was afforded by the commission in specific instances and Type B construction allowed.

In regard to the carrying out of the provisions of Rule 3 — in the few cases where it was found necessary to lay our lines within 100 ft of a dwelling, Type D construction was required by the commission.

In our opinion, one fallacy of such restriction as Rules 2 and 3 provide is that the requirements of heavy-wall pipe give protection for specific dwellings in existence at the time of construction of the line, but in no way prevent other buildings being built along our lines within such distances in the future, in sections where nominal wall pipe has been installed.

Speaking of codes in general we feel that it is highly desirable that our industry design, build and operate cross-country pipe lines under a uniform code regardless of the state through which they pass. We feel that the ASA Code is a good and adequate code because it is the result of the best engineering talent, experience and background available. Accordingly, we earnestly hope that all state regulatory bodies will adopt this code. In this connection it is pleasing to note that the Public Service Commissions of the States of Idaho and Oregon have recently adopted the ASA Code and the State of New Mexico is presently considering the same.

PACIFIC NORTHWEST PNW PIPELINE FEATURE

Buying right-of-way was no cinch — especially with organized opposition

The 2440-Mile Skirmish Line

Donald M. Taylor
The Pipeline Engineer Staff

THERE'S many a landowner who would just as soon share his bathroom with a stranger as share his land with a pipe line. Landowners are by and large individualists — indeed, many of them have sought rural life to free themselves of many of the ties with their fellowman. They regard their real estate holdings as their private world set apart from the rest of the universe.

Fan this individualistic trait with the strong winds of adverse propaganda and you have a hornet's nest, beehive, and rattlesnake den all rolled into one —that is, if you are trying to buy right-of-way. This is what J. Don Creveling, head of the land department of Fish Northwest Constructors found at the northwestern end of this new line.

Creveling is better known as "J. Don" throughout the highly specialized profession of right-of-way buying. He is a gnome-like little man with a St.

Nick midriff and pleasingly tan bald pate. He is as serious as a tree full of owls and normally taciturn — and this is strange for a man who has made his living for about 30 years persuading landowners to sell him easements for pipe lines.

Generally, J. Don is regarded as the dean of right-of-way buyers, and he played a key role in buying land for the Big Inch and Little Big Inch lines during the war.

Battle Lines Are Drawn

When backers of the Pacific Northwest system won a bitterly contested FPC approval for the line, battle lines for the rich heating load of the Pacific Northwest states were drawn. The skirmish line reached all the way from one end of the line to the other. No holds were barred as time and money were at stake. The construction crews had to be off and running in record time.

An association of Pacific's competitors raised a war chest with the purpose of strewing a few tacks along the gas company's path — aimed, if not at stopping the project, certainly at slowing it down. The association organized an adverse propaganda campaign that described the dangers of high-pressure natural gas lines in terms usually associated with nuclear blasts. And to top this, the group advised attorneys along the line that their clients would reap richer rewards by withholding easements for the line from Pacific; forcing the gas company to exercise the right of eminent domain. (This right enables the pipe line company to appropriate any land necessary for the line and settle the value in court.) Trouble is, it's a time consuming task to take landowners to court, and it invariably makes the pipe line company as popular as an internal revenue collector in March.

Such tactics added considerably to J. Don's burden, which was almost overwhelming in the first place. The rewards of winter heating load in the northwest area held rich promise, and the men behind the line were determined to push the project to completion in time to connect up this winter's load. An additional roadblock was thrown up against the right-of-way buyer as financing of the project was not completed until May, 1955, and this gave J. Don a scant 14 or 15 months to complete the buying of some 2440 miles of right-of-way across 5111 separately owned tracts of land. Moreover, the key men in the Fish organization believed in attacking on all fronts and started the project off full-blast scattering pipe line contractors all along the system. This kept J. Don and his hastily organized land department scurrying to keep ahead of construction.

J. Don Creveling, an old pro at right-of-way buying. He headed the Fish Northwest team that purchased 2440 miles in record time for the Pacific Northwest project.

Organized in Six Days

This organization of the land department was completed in 20 days, or just 6 days after office space was obtained in Salt Lake City headquarters. Credit this speed to the reputations of the key men of the Fish companies, who attracted top men from all over the country who wanted to pitch in on the Pacific project.

About two weeks prior to the kick-off date, Creveling supplied abstracters in the first five counties on the south end of the line in Colorado with route maps showing the approximate location of the route. They were asked to prepare ownership lists of all land within one-half mile on each side of the line. From previous experience, J. Don knew that in order to keep ahead of construction he would have to option much of the right-of-way ahead of the survey. With time all-important, it was decided to option all land within this mile wide strip in order to give the survey crews some flexibility in making the permanent location of the line.

The first piece of right-of-way was acquired on May 17, 1955, and by June 1 supervisors and right-of-way agents in the field had the show "on the road" — full speed ahead, with no stops scheduled between Ignacio, Colorado (the south end of the line), and Sumas, Washington (Canadian border on north end of the line).

While organization was completed and work begun on the southern end of the line, the opposition to the north was stirring up some ominous clouds that threatened to match the potent weather of the Pacific Northwest. But there was one keen difference between J. Don's forces and his opposition. The association held an amateur standing at best in the field of propaganda, while J. Don and his forces were pros of long standing in land buying.

Furthermore, he had surrounded himself with some of the ablest men in his profession. Most of them had worked for J. Don on many of the past projects he headed so that little energy was consumed internally by his organization. Relying strongly on his two right-hand men, Morriss Foster and Arthur Kelhofer, J. Don could smell smoke from 1000 miles away and be on hand to put out the fire.

They Came From All Over

Besides, most land men are adventuresome by nature; they like to travel to new places and dote on combining this pleasure with the business of buying right-of-way across strange country. Most of them had looked forward to this job for years—the last transcontinental pipe line race to an untouched natural gas market area in the U. S. Many of them left small businesses or farms in the Southwest to join the forces pushing to open up the Pacific Northwest to gas. They fell to their task with a will.

Keep in mind that as parts of this project were being constructed, other parts of it were being planned. Fish engineers kept up a running battle with the terrain ahead of construction with an eye toward easing the line around most difficult sections — even after the general route had been set. All told, Creveling optioned 6250 parcels of land to accommodate the wanderings of the line and exercised his options on 5111 tracts when the line was pinpointed.

As the intense construction moved into the northwestern states where first-hand knowledge of natural gas was virtually unknown, trouble started coming to a head. An unusually large percentage of landowners were demanding unrealistic prices for their easements, having been advised by newspapers, radio, and TV that the project was expected to cost $200,000,000 plus. Many local attorneys had heeded the propaganda the opposition heaped upon them and in good faith advised clients to force condemnation.

As little court precedent had been established for handling condemnation proceedings, considerable variance was

encountered in the interpretation of the laws.

The result of this was that J. Don's forces spent many a day in court. Often, they could have settled a case at an unfair price for less than the court fight and settlement, but to have done so would have duped the landowners who accepted the company offer as being fair, equitable, and in good faith. Besides, it would have given credence to the opposition rumor that rich spoils went to the recalcitrant.

Artificial barriers sometimes arose to hamper the pipe line, hoping to cash in on the bonanza from the Southwest. As Creveling wryly related, "Never saw so many sub-divisions spring up in my life. Almost every one of them square in front of our right-of-way; and the damages the operators sometimes claimed was fantastic."

It's been said that lack of understanding can lead to misunderstanding. This was certainly true in an area where for years the only news of natural gas usually concerned an explosion or disaster, infrequent as they are.

The Fish Northwest landmen began by carefully explaining the pipe line business to the landowners; and this news by word of mouth travels fast. It has been said that if you tell a secret to two persons and they in turn tell it to two others each in the next 15 minutes, the secret will have spread to the entire population of the earth (if there were no duplication) in about five hours. Fish men made sure true stories were repeated.

With the last tract of land purchased and easements safely filed away, Creveling's men are now turning their attention to settling damage claims. Almost an anti-climax after the hurry-up days of land acquisition, settlements have proceeded smoothly. "I almost miss the frantic days when the crews were right behind us," Creveling concludes. "But it sure is a mighty good feeling to have that pipe in the ground."

PACIFIC NORTHWEST PNW PIPELINE FEATURE

Natural gas, air and water were used.
The jagged terrain made testing difficult in some instances.

How the System Was Tested

Paul F. McBride
Assistant Construction Superintendent for Fish Northwest Constructors, Inc.

TESTING the 1472 miles of main line and 1179 miles of lateral and gathering system pipe in this system required the use of natural gas, air, and water. As gathering system construction operations were carried on along with main line and lateral construction programs, natural gas was available for testing purposes simultaneously with completion of construction on about two-thirds of Pacific's main line from the San Juan Basin through Utah, Colorado, Wyoming, Idaho, and Oregon.

Gas testing operations were begun Apr.l 1, and by the end of June, 503 miles of 26-in. and 22-in. main line and 280 miles of lateral lines and gathering systems had been tested with gas. Earlier in May it became apparent that, due to gaps in the various construction schedules, there was no chance of using gas for testing in the states of Idaho and Oregon if the program was to finish on schedule. The various advantages of air versus water were weighed for the balance of the system, and finally, water was selected as the more convenient, economical, and rapid means of completing the testing program.

Hydrostatic test operations were begun the end of May, and by July 25th, 537 miles of Pacific's main line and 100 miles of laterals had been hydrostatically tested in Idaho, Oregon, and Washington.

Pacific's main line route in Washington, as it follows the Columbia River Gorge on the way to its major customers in Portland and Seattle, traverses extremely rough terrain in Klickitat and Skamania counties. Within a 100-mile section the line crosses five canyons in which the elevation changes 2000 ft each with a horizontal distance of 1 to 1.5 miles. Because steepness of these canyon walls made hydrostatic head pressures excessive, the testing program was further supplemented by the use of air in this area.

Procedures used in carrying on the three types of test operations: After the line was laid and backfilled, a supply of gas was made available from the San Juan Basin for use in cleaning, purging, and testing the southern portion of Pacific's system. Two portable horizontal gas compressors driven by 225-hp gas engines mounted on low bed trailers were used to bring the low-pressure gas from the San Juan gathering system up to maximum test pressure. Beginning at Station 1 near Durango, Colorado, the 26-in. main line was cleaned, purged, and valves set by a Fish Northwest construction crew. Behind this crew followed portable compressors. They were set up at each main line block valve, and taking suction from the San Juan gathering system, they

The Author

Paul F. McBride is assistant construction superintendent of Fish Northwest Constructors. He has been with the Fish organization since May, 1955, when he started as assistant chief engineer. Prior to coming with Fish, he was an engineer with Algonquin Gas Transmission Company for three years. For a period of eight months he was chief engineer of Coates Field Service, Inc., and from 1948 to 1951 he was an engineer in the construction engineering department of United Gas Pipe Line Company. He graduated from Texas A & M in 1948 with a BS degree in mechanical engineering.

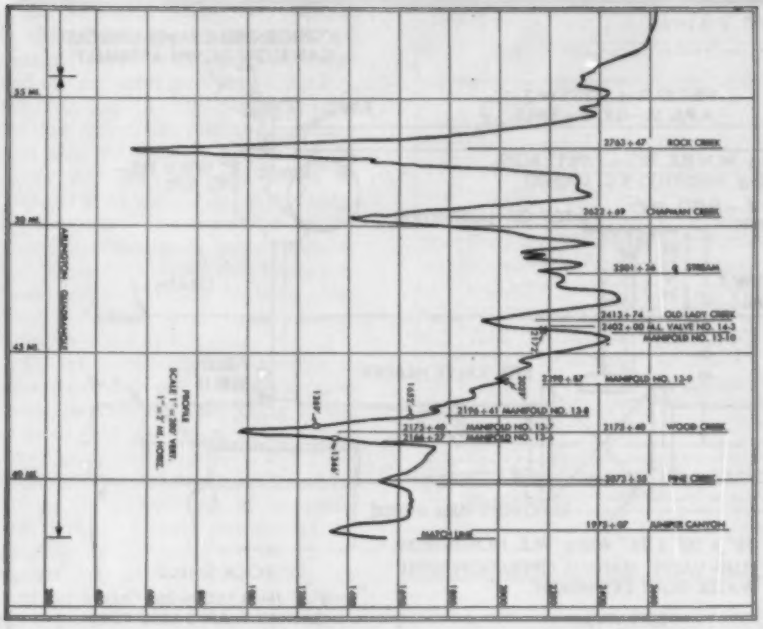

2763 + 47 ROCK CREEK
2622 + 69 CHAPMAN CREEK
3301 + 56 S. STREAM
2413 + 74 OLD LADY CREEK
2402 + 00 M.L. VALVE NO. 14-3
MANIFOLD NO. 13-10
2299 + 67 MANIFOLD NO. 13-9
2196 + 61 MANIFOLD NO. 13-8
2173 + 65 MANIFOLD NO. 13-7
2146 + 32 MANIFOLD NO. 13-6
2173 + 65 WOOD CREEK
2073 + 58 PINE CREEK
1975 + 07 JUNIPER CANYON
MATCH LINE

FIG. 1. **Profile of a 20-mile section** of pipe line in the Columbia River Gorge region. This type terrain made air or gas testing almost a must.

pressured each succeeding valve section to a maximum pressure of 880 psi.

It should be pointed out that all testing methods and procedures were carried out in accordance with the ASA Code for Gas Transmission and Distribution Piping Systems issued in 1955. In accordance with this code, after the line was cleaned and block valves set, a maximum pressure of 200 psi was placed on the line, at which time the line was walked and inspected for leaks.

After the test compressors had been set up and were ready to begin pumping, pressure was allowed to equalize into the section being tested to approximately 500 psi; at which time state police, highway and railway authorities, and individual persons living along the line were notified of the forthcoming test in their area.

As a further precaution, all persons living or working within 500 ft of the line vacated the area during the test. The test was timed so that pressure was brought up on each valve section from 500 to 880 psi during daylight hours. During this time an aerial patrol was maintained over the test section to check for leaks or failures and also to warn any passersby away from the test area. The San Juan gathering system, the 26 and 22-in. main line, the Piceance Creek and Big Piney gathering systems, as mentioned above, were all tested by the end of June according to the foregoing procedures.

Air Testing

A battery of ten air compressors was used to test the 100-mile section of line through the rugged Columbia River Gorge. This section was tested in two halves on either side of the White Salmon River.

Six of the compressors were rated at 600 cfm at 125 psi. They were manifolded in parallel to take atmospheric suction and boost the pressure to the rated 125 psi. From the discharge header on these compressors, the air was piped to a field-fabricated cooler that was dropped in the river. This cooler resembled a ladder with two 30-ft joints of 8-in. pipe connected with 15-ft lengths of 3-in. pipe spaced 8-in. apart. This arrangement not only cooled the air and made the compression more efficient, but it also provided a means of removing a great deal of the moisture from the air.

On the cold side of this cooler, there was a 1-in. blowoff that enabled us to remove about 50 gal of water per day from the air.

Four horizontal compressors (belt driven, single-cylinder, double-acting) boosted the pressure on up to the 880 psi required for the final test.

Here is the procedure used in testing and cleaning the two 50-mile sections. First, a 10 to 12-mile section of line was bullplugged and used as a storage bottle for air to clean the first section of line. It was pressured to 125 psi, and then cross connected to the 50-mile section on the west side of the river. Pigs were run and the first half of the line was clean.

For the next operation, this 50-mile section served as a bottle to supply air for cleaning the 50-mile section on the opposite side of the river. After both sections were cleaned, air pressure was raised to final test pressure of 880 psi in the first 50-mile section. After it had been tested, the air was equalized into the clean but untested 50-mile section across the river. After the pressure was equalized, the compressors were tied-in to take suction from the tested section to raise the pressure to 880 psi in the untested section.

During these tests, men were stationed at block valves along the line and in case of a break, they closed the valves as rapidly as possible to conserve the air in the line.

Hydrostatic Testing

Hydrostatic testing operations require a different procedure from that used in gas or air testing. After a sec-

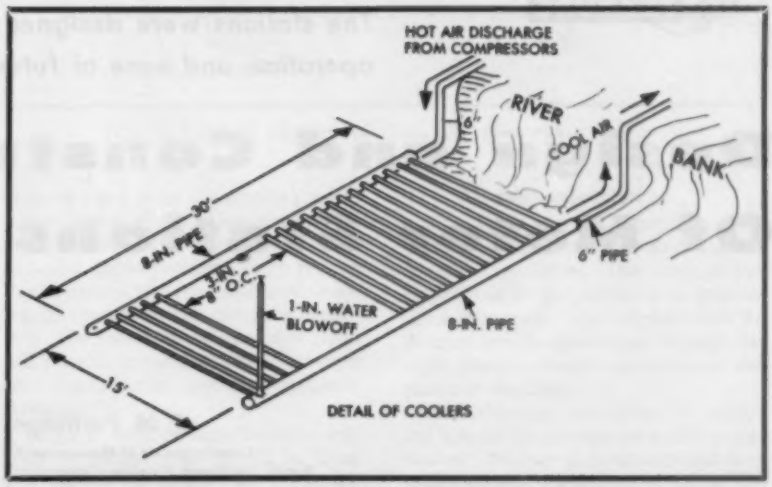


FIG. 2. **Detail of the cooler** made from two lengths of 8-in. pipe with 3-in. pipe on 8-in. centers in between. This entire section laid in the stream. The blow-off was on the lower part of the cool side.

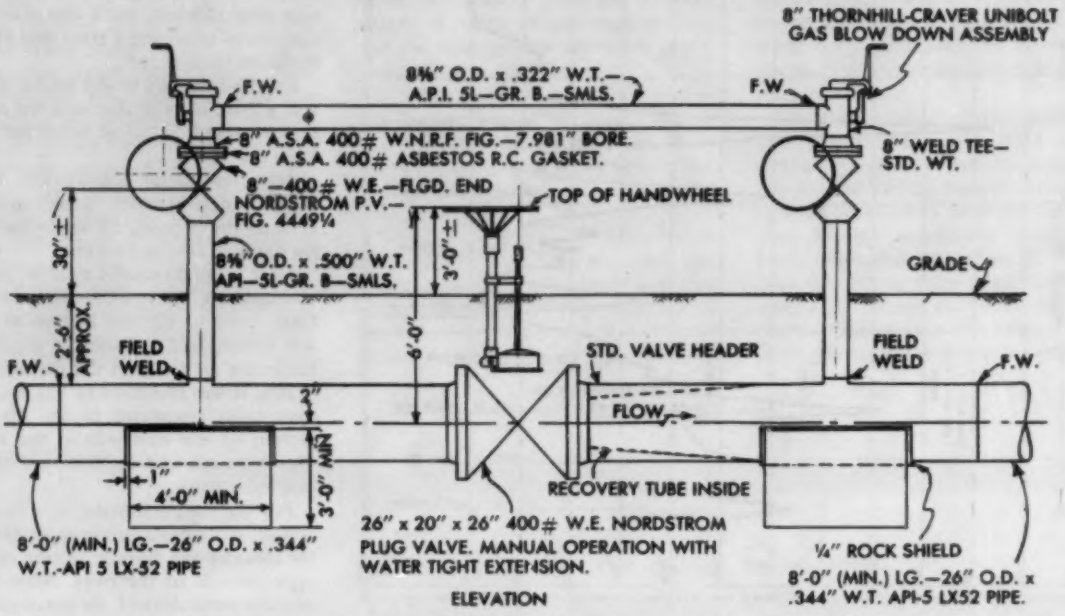


FIG. 3. **Elevation detail** of the main line valve settings.

tion of the line was completed and before main line block valves are set, a profile of the pipe line was made using either U.S.C. and G.S. quadrangle maps or data obtained from field survey parties. From this profile, the pipe line was subdivided into sections so that during the testing the hydrostatic head would not exceed the calculated specified minimum yield strength of the pipe. After manifolds were set, each section was filled from a convenient river or creek. Williams Pressure Service Company of Shreveport, Louisiana, was employed to carry on the filling and testing operations of this system. After the section of line was filled and tested, manifolds were cut and sent ahead.

To remove the water after the hydrostatic tests, Fish crews used a pig-launching manifold. First, a single pig was launched against the water and run to the end. Next the remaining four pigs were launched at 25 to 30-min intervals to clean most of the remaining water from the line.

At the end of this operation, the test gas that had a dew point of about 35F at 500 psi came out with a dew point of about 60F at the same pressure. The remaining water will be absorbed by the dry pipe line gas.

PACIFIC NORTHWEST PNW PIPELINE FEATURE

The stations were designed for low-temperature operation and ease of future expansion

Design and Construction Of Meter Stations

F. M. Partridge
Superintendent of Measurement, Pacific Northwest Pipeline Corporation

THE measurement of gas throughout the Pacific Northwest system is by means of standard meter stations as specified in Table 1. In addition to the sales, purchase, and operating meters in the table, there are 4-in., 3-in., and 2-in. orifice meters at each well in the production fields.

Fig. 1 shows the general layout of a sales meter station. The various classes of stations are similar and vary only in the size and number of meters and regulators. It can be noted from Table

I that the station design is very flexible in that the station capacities can be changed easily by changing the meter and the regulator port size. Class I-A, I-B, I-C, and I-D are identical except for the meter size and the regulator port size. To increase the station capacity a Class I-B station can be changed to a class I-C or I-D by changing the meter. The largest size in any major classification is never installed initially as there would then be no provision for increasing capacity. No Class I-D, II-C, or III-C stations are being installed at this time.

To insure the highest accuracy in measurement all orifice meters for sales meter stations are sized using a beta ratio of 0.60 and 50-in. range orifice meter gages. All large sales meter stations make use of senior orifice meter fittings for convenience in inspecting orifice plates without interrupting the gas flow or operating bypass valves. Square root orifice meter charts are used on all orifice meters throughout the system.

For safety the regulation is made in two steps even though one is all that the ASA Code requires. The two-stage regulation was specified to minimize regulator freezing problems and to provide additional safety protection. In addition a relief valve is provided to prevent overpressuring the downstream piping in the event that both of the regulators should fail to open.

At several locations in the system recorders are being installed to provide a continuous record of specific gravity, heat content, and dew point of the gas. One of the problems to be met on this project is the prevention of freezing of the gas in the pressure regulators. The record of the gas dew point will provide a warning when measures are required to prevent regulator freezing.

A great deal of consideration was given to measures that could be taken to avoid the freezing of the gas in the vicinity of the pressure regulators. The procedures that were incorporated into the design are:

TABLE 1. Meter Station Data.

CLASS	METER	REGULATORS	REGULATOR PORTS	MEASUREMENT PRESS. APPR.	BLDG. SIZE	NET CAPACITY PR. DR.	NET CAPACITY PER DAY*	NUMBER OF STATIONS PLANNED
I-A	800 Metric	2-1" Reliance "F"	9/16", ¼ area	150#	10' X 16'	15	259	11
I-B	2500 Metric	2-1" Reliance "F"	9/16", ¼ area	150#	10' X 16'	37	630	13
I-C	5000 Metric	2-1" Reliance "F"	5/8", ½ area	150#	10' X 16'	61	1,050	16
I-D	2-5000 Metric	2-1" Reliance "F"	¼ 1/16", Full area	150#	10' X 16'	134	2,300	0
II-A	3" Orifice	2-2" Reliance "F"	3/4", ¼ area	400#	16' X 22'	163	2,630	8
II-B	4" Orifice	2-2" Reliance "F"	1 1/16", ½ area	400#	16' X 22'	245	4,160	16
II-C	6" Orifice	2-2" Reliance "F"	1 7/16", Full area	400#	16' X 22'	530	9,000	0
III-A	6" Orifice	2-4" Grove	Not Applicable	400#	18' X 30'	530	9,000	0
III-B	8" Orifice	2-4" Grove	Not Applicable	400#	18' X 30'	930	16,700	0
III-C	10" Orifice	2-4" Grove	Not Applicable	400#	18' X 30'	1,500	25,500	0
IV-A	2-8" GE	4-4" Grove	Not Applicable	400#	30' X 36'	1,980	33,600	1
IV-B	2-10" GE	4-5" Grove	Not Applicable	400#	30' X 36'	2,930	50,000	2
IV-C	2-12" GE	4-6" Grove	Not Applicable	400#	30' X 36'	4,062	69,676	2
IV	SPECIAL AS REQUIRED							7
							TOTAL	84

* Includes allowance for load pattern of typical distribution meters.
** Class I-D change pending, formerly 1-3" orifice meter.

Note: Normally, the initial installation will not be of the largest size in any one class group. All sizing is to be done by the measurement department due to load patterns and other factors.

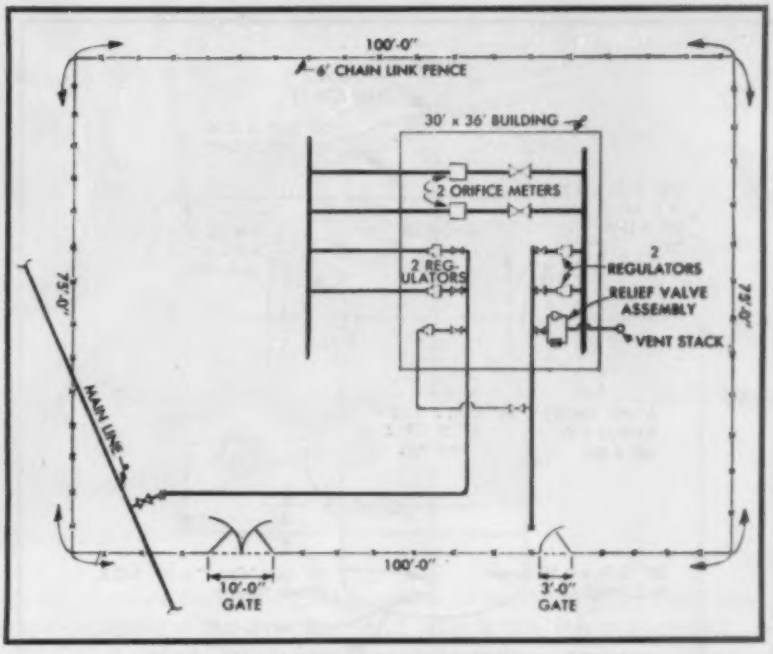


FIG. 1. **Typical layout** of Class IV sales meter station.

(1) Alcohol Injection

Fig. 2 is a view of a partially completed station showing the first stage of pressure regulation. The tank at the upper part of the picture is to provide alcohol storage. The alcohol will be dripped into the gas stream through the sight glass shown just upstream of the pressure regulator.

Consideration was given to applying heat to the gas upstream of the regulators. Because it is anticipated that under normal operation conditions the gas will be extremely dry, it was felt that the application of heat would not be required. When the dew point is

The Author

F. M. Partridge is a native of Salt Lake City, Utah, where he obtained his engineering training at the University of Utah. After leaving the university in 1938 he was with the U. S. Geological Survey for a year and a half. In 1940 he went with Southern California Gas Company and for 15½ years he worked in many phases of the gas business with the emphasis on gas measurement.

In June, 1955, he left the Southern California Gas Company to work on the Pacific Northwest Pipeline project.

Partridge has been chairman of the Pacific Coast Gas Association and California Natural Gas Association Gas Measurement Committees, and is a past president of the Southern California Meter Association. He is now chairman of the American Gas Association Gas Measurement Committee.

He is a member of the American Society of Mechanical Engineers and is a registered professional engineer.

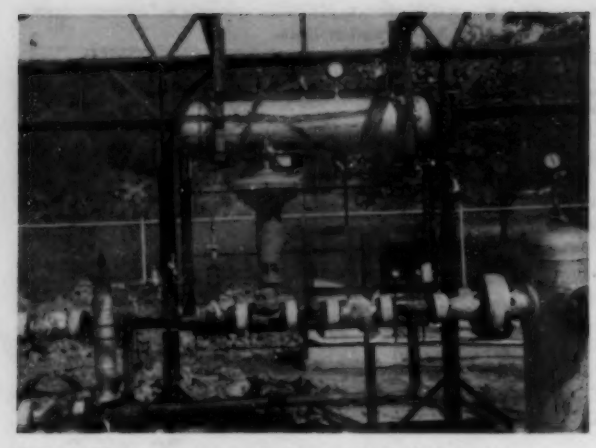


FIG. 2. **First stage** regulation and alcohol tank.

FIG. 4. **Orifice meter** and second stage regulation.

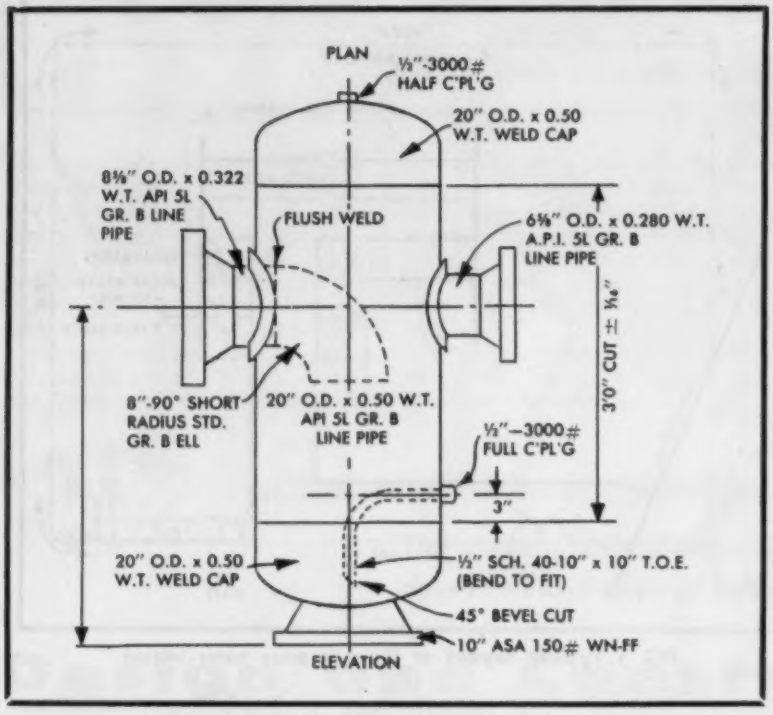

PLAN
½"-3000# HALF C'PL'G
20" O.D. x 0.50 W.T. WELD CAP
8⅝" O.D. x 0.322 W.T. API 5L GR. B LINE PIPE
FLUSH WELD
6⅝" O.D. x 0.280 W.T. A.P.I. 5L GR. B LINE PIPE
30" CUT ± 1/16"
8"-90° SHORT RADIUS STD. GR. B ELL
20" O.D. x 0.50 W.T. API 5L GR. B LINE PIPE
½"—3000# FULL C'PL'G
3"
20" O.D. x 0.50 W.T. WELD CAP
½" SCH. 40-10" x 10" T.O.E. (BEND TO FIT)
45° BEVEL CUT
10" ASA 150# WN-FF
ELEVATION

FIG. 3. **Drip bottle.**

high enough so that the probability of freezing is indicated meter inspectors will be dispatched to turn on the alcohol drippers as required.

(2) Pressure Regulators

All regulators on sales meter stations are of the single seat type because the flow through these regulators is streamlined and less turbulent. This should make them less susceptible to the formation of gas hydrates or ice crystals in the regulator body. The turbulent flow of gas through the body of the conventional doubleseated regulators provides favorable conditions for hydrate formation. The unobstructed streamline path for the gas leaving the seats of a single seated regulator will tend to blow away any hydrates or ice crystals that are formed.

(3) Drip Bottles

Downstream of each regulator a drip bottle is provided to act as a cushion or volume chamber between the regulators and also as a collector of dust, liquids, ice crystals, or hydrates. A drawing of one of these drip bottles is shown in Fig. 3. Another function of this vessel is to reduce the velocity of the discharged gas from the regulators and deflect any entrained materials to the bottom of the vessel where it can be blown out as required.

Immediately downstream of each regulator is a flanged venturi fitting that is designed to reduce the velocity of the gas discharged from the regulator so that it is less than the velocity of the gas going into the regulator. This lowered velocity of the discharged gas will reduce the sound level produced and also will reduce the probability of the formation of ice crystals and hydrates.

Also shown in Fig. 2 is the gas dryer for the instrument gas and the pressure controller that is used in connection with the regulators shown. This is the first stage of pressure reduction. The main line pressure ahead of the sales meter stations generally will be between 500 and 800 psi. The first stage regulator will reduce this pressure to 400 psi. The second stage regulators then reduce the pressure to the normal delivery pressure of 150 psi.

Fig. 4 shows the interior of a completed sales meter station downstream of the view that was shown in Fig. 2. Here can be seen, starting from the left, the senior orifice meter fitting, the orifice meter gage, the pressure controller, and the second stage pressure regulator with the flanged venturi fitting immediately downstream. All orifice meter gages have three pens on them, which record respectively the static pressure, the differential pres-

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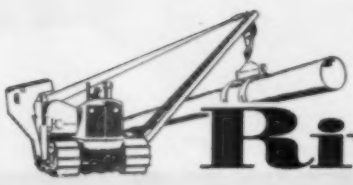

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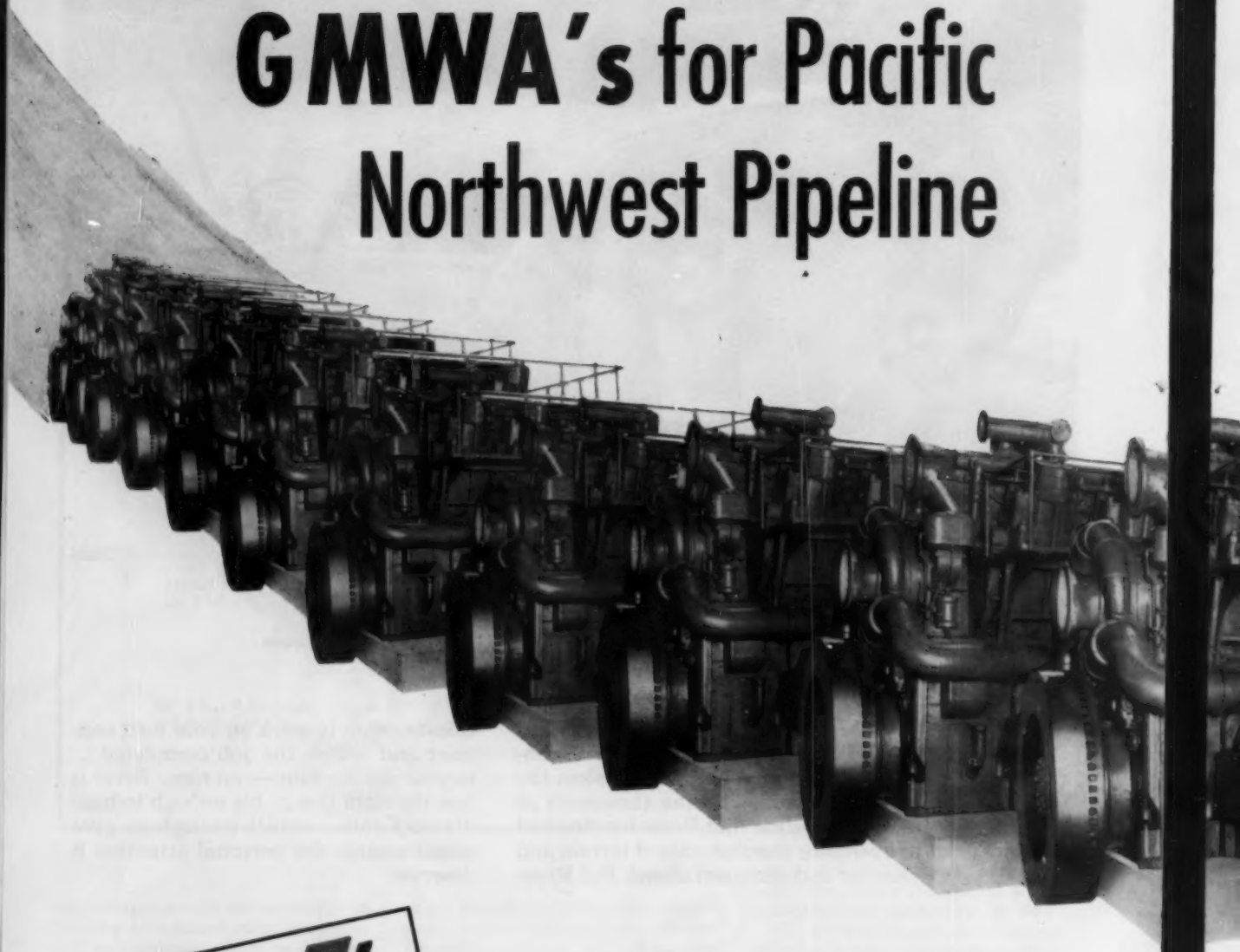

ANGLE

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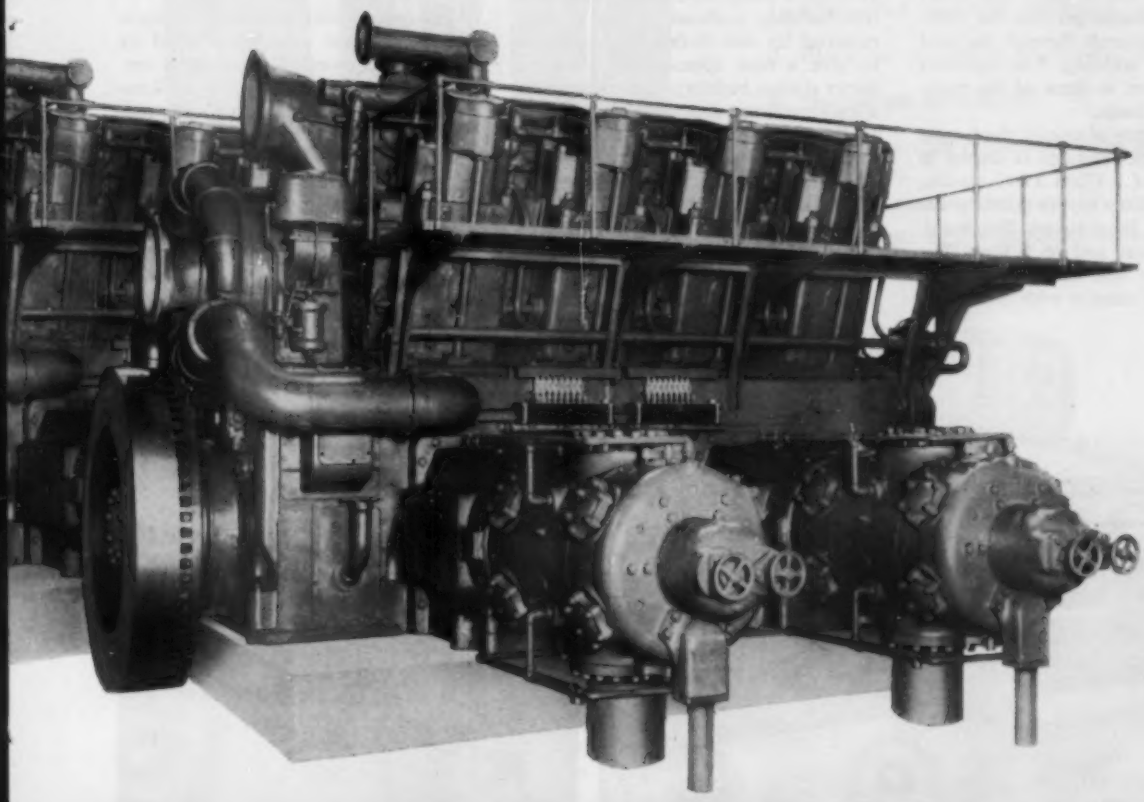

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FIG. 5. **Second stage** regulation and relief valve assembly.

FIG. 6. **Large sales meter** station under construction

sure, and the temperature of the flowing gas.

The station piping downstream of that shown in Fig. 4 is shown in Fig. 5. In this view can be seen the second stage regulator, a 2-in. by 6-in. flanged venturi fitting, the drip bottle, and downstream valves. Going on toward the right is a block valve and relief valve, which discharges into the vertical pipe that extends through the roof of the station building. The regulator bypass is shown in front of the regulator and drip tanks.

A general view of one of the largest sized sales meter stations is shown in Fig. 6. This is a Class IV-C station, which is one of the supply points to the city of Seattle, Washington. This building is 30 ft wide and 36 ft long. The building cover will consist of corrugated asbestos cement with two translucent panels in the roof to provide good lighting conditions. A closer view of the equipment in this station is shown in Fig. 7. At the left are two 12-in. orifice meter tubes and on the right portion of the picture can be seen two regulators. These provide the second stages of pressure reduction. A view of a completed sales meter station building is shown in Fig. 8. The material for this building was chosen to give a neat appearance. All sales meter station buildings are enclosed in a cyclone fence similar to that shown in this picture. The smallest stations have a fenced area of 100 ft by 50 ft. The largest stations have 100 ft by 75 ft or 100 ft by 100 ft.

Construction of the production meter stations is being done in connection with the wellhead dehydrators, which are covered in another section of the Pacific Northwest Story.

Sales meter construction started at Mancos, Colorado, near the beginning of the line in December, 1955, by a Fish Engineering crew. This crew worked up the line and built all sales meter stations to the Idaho-Oregon state line. This work was completed in September.

The sales meter stations in Oregon and Washington were constructed by the Hydrocarbon Construction Company. One crew, working out of Kennewick, Washington, began construction about April 1 of this year. Another crew started work out of Seattle, Washington, about May 1. This construction work is scheduled for completion so that the stations will be ready to serve the people of the Pacific Northwest as soon as the gas in the pipe line reaches them.

FIG. 7. **Close-up of large** station under construction.

FIG. 8. **Main line check meter** station, Plymouth, Wash.

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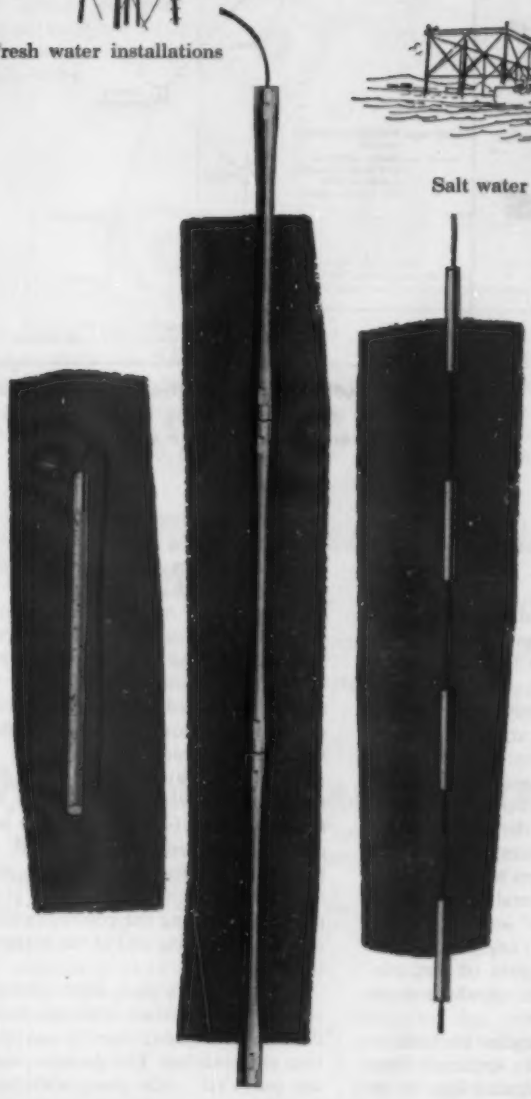

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PACIFIC NORTHWEST PIPELINE PNW FEATURE

The company decided on VHF radio used with leased wire lines

Communications

William C. Brady
Superintendent of Gas Control,
Pacific Northwest Pipeline Corporation

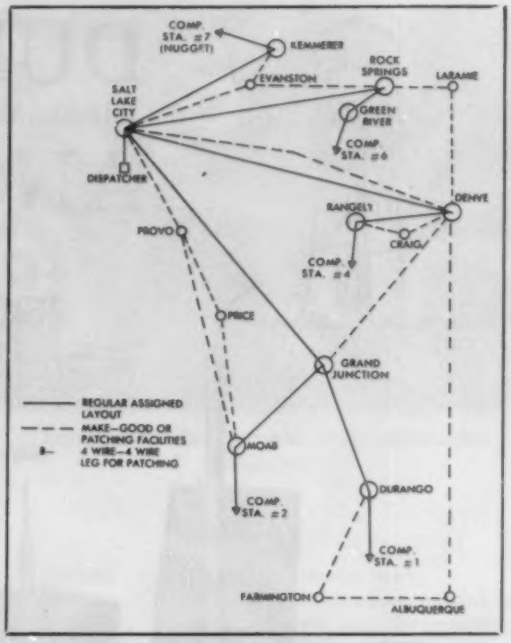

FIG. 1. Southern part of the wire line system. Note the many patching (or alternate) circuits that can be used in time of emergency.

AN operation such as the Pacific Northwest Pipeline project, requires proper intelligence at the right place, in the right hands, at the right time, to serve properly cities, towns, and industrial consumers along its route. Pacific's operation reaches from the gathering systems of the San Juan Basin in New Mexico to the sales meter station at the most extreme end of its pipe line. This means our communications must cover more than 2300 miles.

When this project first developed, the engineers helping formulate plans and specifications had several modes of communications to draw on. For years open wire lines have served the industry well. These open wire lines were expanded to render more service with the advent of carrier equipment to increase their capacity. VHF radio equipment was available on a basis far beyond the experimental stage and was proved not only in the pipe line industry, but also in many other fields.

The design engineers had the experience and data on several long distance microwave systems of other gas transmission companies. They had the experience and techniques of the telephone companies across whose areas this system was to go.

With all these various methods at their disposal the only approach from an engineering standpoint was to investigate each one and come up with a system that would serve the pipe line and still be both economical and practicable.

Investigations and studies were begun. First, would it be possible to rent "pin space" from existing facilities and install carrier thereon. How much pole line would we have to build? This study went from one end of our system to the other. We got an answer.

Secondly, two suppliers of microwave equipment were authorized to undertake an actual field survey to determine what a microwave system would cost. Sites were spotted, access was investigated, and an estimate was made as to how much it would cost us to maintain the equipment if it were to be installed. (As you know, this pipe line traverses some of the roughest terrain in the United States. Winter brings severe wind, snow, ice, and extremely low temperatures.)

While these studies were in progress numerous conferences were held with the telephone companies. Needs were outlined, the operation explained, and problems discussed so that the engineers could evaluate them and give a proposal covering the communications required from one end of the system to the other.

With the data thus accumulated, a report was prepared, with recommendations for management's consideration and decision. The decision was to use our VHF radio along with leased facilities from the telephone companies in the areas crossed.

The telephone system, which is now complete, consists of a full period, two tone signaling system from Station 1, Ignacio, Colorado, to Salt Lake City, our central dispatch point. This south line connects Salt Lake City with Station 1; Station 2, Moab, Utah; Station 4, Rangely, Colorado; Station 6, Green River, Wyoming, and Station 7, Kemmerer, Wyoming.

The north line ties Salt Lake City

The Author

William C. Brady joined Fish Northwest Constructors in October, 1955, and was recently appointed superintendent of gas control. This includes communications, cathodic protection, and gas flow. From 1948 to 1955, he was with Texas Eastern Transmission where he had charge of electrical design and construction and advanced to assistant administrative engineer. From 1946 to 1948 he worked for the FPC in Atlanta, Georgia, on hydroelectric power studies. Brady graduated from Catholic University of America, Washington, D. C., with a BS in electrical engineering in 1943 and promptly entered the U. S. Army Signal Corps. He was discharged a 1st Lieutenant in 1948. Brady is a native of Utica, New York.

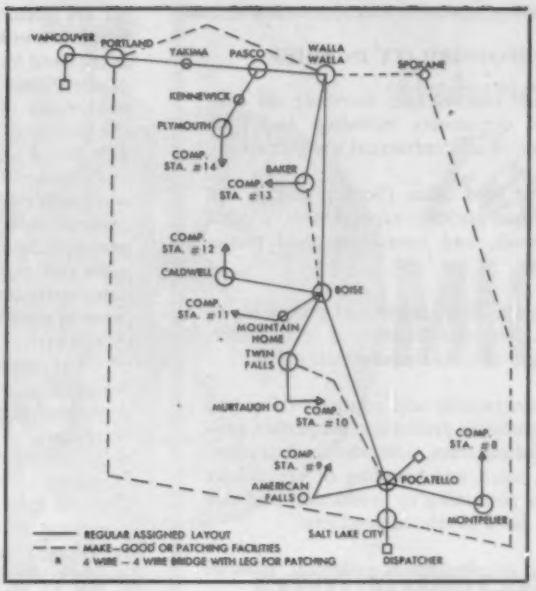

FIG. 2. Northern part of wire line system. Both systems are used in conjunction with VHF radio stations and mobile units.

to Station 8, Montpelier, Idaho; our division office at Pocatello, Idaho; Station 9, American Falls, Idaho; Station 10, Murtaugh, Idaho; Station 11, Glenns Ferry, Idaho; Station 12, Caldwell, Idaho; Station 13, Baker, Oregon; Station 14, Plymouth, Washington and our division office at Vancouver, Washington. At Salt Lake these two lines appear at our dispatcher's desk for operational purposes and on our dial PBX for administrative purposes.

At each station this circuit has outlets in the superintendent's office and residence. There is selective ringing for each of these two appearances and also a master ring, for each leg, that will call all stations on the line.

Fig. 1 and 2 diagram the telephone circuits that link various installations on the North and South Circuits. The solid lines indicate the normal routing, and the dash lines indicate the alternate routes over which service could be routed in case of failures between junction points of the telephone companies plant.

The VHF system of eight base stations will enable efficient direction of the operations of all mobile units in these areas for the proper operation and maintenance of the line.

At the central dispatch point in Salt Lake City, now in operation, is a 200-line dial system supplied by Mountain States Telephone Company. This initial installation will serve Pacific Northwest in the early years of operation. The dispatch office will be in full control of the north and south full period circuits through its own individual switchboard.

PACIFIC NORTHWEST PNW PIPELINE FEATURE

The methods of cost accounting and sharp organization enabled Fish to convert speedily all construction costs into properly unitized property accounts at the end of construction

How Accounting Was Set Up

G. Byron Smith
Assistant Controller, Fish Northwest Constructors, Inc.

THE ultimate goal of any system of accounting during pipe line construction is to convert all construction costs into properly unitized property accounts at the end of the construction program. Certainly, this was the goal of Fish Northwest Constructors, Inc., when construction of the Pacific Northwest system began in May, 1955.

Overnight, Pacific found itself a going concern with leasehold interests in approximately 460,000 acres, both developed and undeveloped, and joint interests in about 145 gas wells. Because of the urgency of developing gas supplies, Pacific immediately undertook a major drilling program to develop this vast acreage.

At the same time, Fish Northwest Constructors, acting as agent for Pacific, set about the task of planning, designing, and constructing the large transmission and gathering system with related facilities. The target goal for gas deliveries set a fast pace for construction and an equally fast pace for completion of accounting activities.

The Accounting Organization

The accounting organization, which was established under the controller, consisted of two assistant controllers, one to supervise construction accounting activities, the other to supervise drilling and production accounting.

Construction accounting activities had to move into high gear at the outset because of the magnitude of the project and the speed of construction at the very beginning of the job. Here is a brief outline of the organization of the section and the corresponding responsibilities.

In addition to the accounting responsibilities, the Insurance Department as well as the Personnel Department and Office Services fell under the Controller's jurisdiction. The above organization which is presently at its peak consists of approximately 100 people, 80 of which are engaged in accounting functions and the remainder performing insurance, personnel and office services functions.

The functions and responsibilities of the Controller's Department are somewhat more refined than the usual op-

SECTION	RESPONSIBILITY IN BRIEF
Contract Audit:	Maintain control and distribute all contractual documents including audit for payment of all contractual obligations.
Field Audit:	Audit of field office (both pipe line and compressor station) expenditures, control field funds, and coordinate field procedures.
Disbursements:	Final audit, preparation and processing of checks, and maintenance of records pertaining to all cash disbursements.
Gas Accounting:	Maintain records and control of Pacific's participation in production properties, payments of royalties, overrides, and gas purchases, sales, and handling of various tax matters pertaining to production and sale of oil, gas and related products.
Production Accounting:	Control of production materials, audit of joint interest billings, etc.
Payroll:	Maintain payroll records, audit, payment and recording of all company payrolls and related tax matters.
Machine Accounting:	Key punch all contractual and purchase order committments and cash expenditures, mechanical accumulation of costs, preparation of special cost reports, etc.
Plant Accounting:	Preparation, accumulation and coordination of all construction costs, control of inventories, preparation of special cost studies, etc.
Ad Valorem Taxes:	Preparation and maintenance of all records, control, renditions and assessments relating to ad valorem tax matters.
General Corporation Taxes:	Maintain records, file appropriate returns, all general corporate taxes.
General Accounting:	Preparation and control of company's books of account, subsidiary records of receivables and payables, financial statements, etc.

erating organization of a natural gas transmission company. **However, in order to properly account for and control approximately $210,000,000 of construction expenditures in a relatively short construction period of 18 months, it was necessary to refine the organization to this extent.** All accounting control was centralized in the home office in Houston, Texas, where all major disbursements for materials, contractual obligations, payroll, etc. were made. Of course, much of the detailed accounting and material control functions were, of necessity, performed by competently trained personnel working in the headquarters office in Salt Lake City, Utah, and Albuquerque, New Mexico, and in numerous field offices throughout the seven states in which the production and transmission facilities of Pacific are located.

To enable us to perform our major tasks, that of cost accumulation by segments, a machine tabulating installation was required. On a project of this size it is necessary for budget control purposes, to not only maintain adequate control of day to day costs but, in addition, to maintain day to day control of both contractual and purchase order working time.

The construction costs on this project are accumulated on the **construction work-order system of accounting** as required by the rules and regulations of the Federal Power Commission. A **work-order system,** several months in the planning, was established to segregate major elements of the production and transmission system. **A separate work-order was issued to accumulate costs of each pipe line schedule, compressor station, major river crossing, sales and supply lateral, purchase and sales meter station, fee land, major segment of right of way, etc.**

The system provides a means for the physical segregation of all facilities within a state. For instance, where a pipe line schedule extended beyond state lines, then separate work orders were issued for that portion of the schedule in each state. Likewise, the terms of the contract covering installation were so designed as to permit segregation of the work performed by work orders. This segregation of physical properties is necessary for many purposes, including segregation for ad valorem tax and sales and use tax reporting purposes.

It was further necessary that within each work order total costs be segregated by type. To accomplish this, a system of construction sub-accounts was designed to segregate the element of costs by units such as materials, overheads, installation costs, right-of-way acquisition costs, right-of-way damage settlements, etc. The system of construction sub-accounts was prepared so that it would provide for costs charged to any type of work order, thereby eliminating the necessity of developing separate systems of sub-accounts for different types of work orders, such as a work order covering a compressor station and a work order covering a pipe line schedule.

This system enables us, at the close

The Author

G. Byron Smith is the assistant controller of Fish Northwest Constructors, Inc., and assistant secretary and assistant treasurer of both Pacific Northwest Pipeline Corporation and Northwest Production Corporation. He joined Fish Constructors in 1949 and advanced to staff assistant to the secretary-treasurer of Fish Engineering Corporation. He was graduated from Baylor University with a BBA in accounting and has served with Haskins & Sells, Dallas, Texas, and The Shamrock Oil and Gas Corporation, Amarillo, Texas. He is a certified public accountant.

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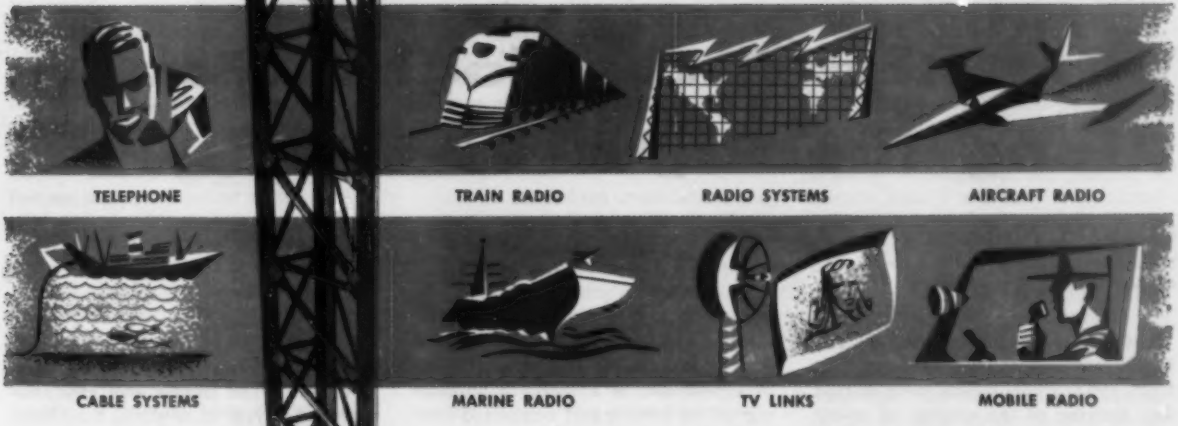

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of each month, to tabulate all construction costs by work orders and in addition, provide the detail of costs of work orders, where necessary. Also, all committments, both contract and purchase order, are tabulated in the same manner enabling us to tabulate total costs, both expended and committed at each month end. This method of accounting readily lends itself to budgetary control by segments of the system. This is most important on a project of this size where construction expenditures must be kept within the financed budget. Also this system of accounting enables us, by means of machine correlation, to provide Management with special cost reports prepared other than on a work order segregation basis.

The ultimate goal of this system of accounting is to permit a conversion of all construction costs into properly unitized property accounts at the conclusion of the construction program. This must be accomplished in order to conform to the Commission's property accounting requirements. It is also essential that accurate costs be maintained after operations are commenced in order to correctly compute depreciation, cost of service, and for many other purposes that are necessary to an overall efficient operation by any natural gas pipe line company.

Unitization Section

The story of Fish Northwest Constructors' Unitization Section proved to be so interesting to the editors that it was decided to run a longer and more detailed article in next month's issue of The Pipeline Engineer. The work of this section was highly important to the success of the Pacific Northwest Project.

PACIFIC NORTHWEST PNW PIPELINE FEATURE

Early man may have subsisted on plant foods 8000 to 9000 years ago in Northwest. Hunting and fishing may have come later. This is just one of the finds from the more than 150 sites discovered along the Pacific Northwest system

What the Archeologists Found Along the Right-Of-Way

Dr. Jesse L. Nusbaum

Senior Archeologist, National Park Service and U. S. Department of Interior

WHEN construction of the Pacific Northwest system got underway in June, 1955, archeological work started too. Because of the number of active construction spreads, a maximum of three teams of two archeologists each were required to examine intensively on foot the right-of-way ahead of any bulldozer disturbance for surface evidence of sites. Then in the wake of trenchers they examined progressively all trench wall profiles for subterranean evidence of prehistoric occupancy. Lastly, they completed either the testing or, with labor assistance, the salvage excavation of sites for materials of significance in advance of bulldozing or the lowering of completed line.

Just keeping pace with construction on so many far-flung spreads in this running competition between "bulldozers and trowels" was an arduous task that left little time for laboratory research on recovered materials and related scientific records prior to completion of the fieldwork. For this reason only preliminary highlights of the archeological findings can be reported at this stage.

To date, the surface survey has been completed, and trench wall examination and salvage excavations have been nearly finished on 1487 miles of main line, and on nearly 1500 miles of laterals and gathering lines.

The prehistoric culture potentials along this right-of-way were practically unknown, even to professional archeologists, except in the San Juan Basin, and for some distance along the Columbia River in southern Washington.

The Search Through Unknown Regions

The intensive surface survey through these hitherto archeologically unknown regions northwest from Buhl, Idaho, revealed a total of *26 sites — two in Idaho, four in Oregon, and 20 in Washington* — many of which were tested by excavation of 5-ft-sq pits to sterile soil. On such basis, four sites were selected for complete salvage excavation as important contributors to the pre-history of the Northwest.

Complete excavation of the Wenas Creek habitation site near Yakima,

The Author

Dr. Jesse L. Nusbaum is senior archeologist of the National Park Service and since 1927 he has been consulting archeologist for the U. S. Department of Interior. He began his archeological career with the Museum of New Mexico in 1907 and participated in the field work in Mesa Verde National Park and in the great Mayan ruins of Quirigua in Guatemala. He also did work in Spanish Honduras and Yucatan, in addition to New Mexico, Colorado, and Utah.

On a six-year leave of absence from the Department of Interior, Dr. Nusbaum served as director of the Laboratory of Anthropology in Santa Fe. He worked with El Paso Natural Gas Company, establishing a precedent for pipe line archeology. In 1954, Douglas McKay, secretary of interior, conferred the department's highest honor award — the Distinguished Service Medal and Citation — on Dr. Nusbaum.

Pueblo boy's pot? Ditching machine cut right across the ruins of this 1000 year old home (see upper right). Ventilator opening is shown at left and a wall cache at the right.

Washington, on the Wenatchee lateral, yielded two human burials and nearly 1400 artifacts, many of which were arrowheads. **The most important result was clear stratigraphic evidence of six superimposed levels or layers of occupancy, which fills the gap in cultural history between the present Yakima Indians and their ancient ancestors.**

Early Man Not a Hunter?

Excavation of the Columbia Ridge site, two miles north of Columbia River near Goldendale, which resulted in the recovery of almost 200 stone and bone artifacts, was of great importance, owing to the large number of edge-ground cobbles, or grinding tools, found. Only one other grinding tool of this type, found in the lowest cultural level of a cave site near Vantage, Washington, has been described. This level of the cave site has an antiquity of 8000 to 9000 years, according to geochronological dating methods. If this antiquity is eventually substantiated for the Goldendale site, the archeologists have unearthed evidence of a very early subsistence pattern based primarily on gathering of native plant foods —not the hunting and fishing habits of historically recorded Indians of this region.

Ninety-six stone chopping, cutting, and grinding tools were recovered from the test excavations of the camp-site on the East Fork of Lewis River near Battleground, Washington.

Stone-Age Quarry

About 15 miles south of La Grande, Oregon, the main transmission line centrally traversed an extensive fine-grained basalt quarry site, the first of its kind on the Plateau to become known. More than a hundred large, crudely flaked bi-pointed blades were collected from the surface and a series of test excavations. Literally thousands of percussion chipped flakes, as well as crudely shaped and unfinished artifacts, littered the surface of this great quarry location.

Despite its distinct importance, the pipe line course along the Snake River Valley from Buhl across southern Idaho and southwestern Wyoming, and southerly through western Colorado and eastern Utah, to the Colorado River crossing at Moab, had been all but unexplored by other than local amateur collectors. Findings within the narrow right-of-way were disappointingly meager — evidence of shallow temporary camping and stone chipping locations of early and later transients, seasonal hunting and foraging principally, with occasional isolated artifacts. The more comprehensive and representative private and museum collections that the pipe line archeologists inspected had been gathered from areas distant from the pipe line right-of-way.

Between the Colorado River crossing and Cahone, Colorado, 13 minor occupation sites were found; however, beyond Cahone, all right-of-way traverses the San Juan Basin region of Colorado and New Mexico, an area as notable for the richness of its archeological resources as for its natural gas reserves.

One team of two archeologists has been diligently working nearly every day for 13 months on surface survey, trench examination, and salvage excavation of significant sites and structures on the easternmost 71-mile section of the main line from Cahone to Compressor Station No. 1, near Ignacio, Colorado, and on the presently developed system of 10 trunk lines and related feeders, aggregating 222 miles, which radiate to gather San Juan Basin gas.

To date, Albert Mohr and his wife, working as a team, have found a total of 86 sites — 30 on the 71-mile length of main line and 56 sites on the 222-mile gathering system. Not subject to pipe line construction threat but incidentally recorded in the interest of science were 9 additional sites closely bordering the main line right-of-way, and 21 sites bordering the gathering system.

In view of the fact that no scientific excavation had been made within the vast area of the gathering system, nor for several miles on each side of the main line from Cahone to Ignacio, 21 of the 86 sites within these rights-of-way, either exposed on the surface or their character and location revealed in sub-surface trench wall profiles, were considered of sufficient significance to merit salvage excavation.

Pit house was uncovered by the trenching machine in the Rocky Mountains.

Basketmaker II and Basketmaker III

The results of salvage excavation in these previously uninvestigated regions has thrown more light on development of diversified forms of pit and surface dwellings and their related artifacts from pre-ceramic *Basketmaker II* people of the San Juan Basin region of about 150-60 A.D. (who first introduced corn agriculture) through the transitional forms of deep to shallow pit pit dwellings of *Basketmaker III* times (and the invention of fired pottery, to the jacal (pole, abode, and brush) dwellings of *Pueblo I and II* times that led in the 800-900 A.D. period to the development of simple masonry dwellings of one to several rooms. No ruins of the ensuing *Classic Pueblo III* period (900-1300 A.D.), which culminated in the development of multi-storied and compartmented masonry pueblos and cliff-dwellings (as in Chaco Canyon National Monument and Mesa Verde National Park), were encountered on San Juan right-of-way. The Mohrs did, however, find and excavate the residual remains of several Navajo hogans of the early historic period.

In summary, sites excavated in the San Juan Basin included three *Basketmaker II* sites, two *Basketmaker III* sites, five *Pueblo I* sites, one *Pueblo II* site, three transitional forms of *Basketmaker III-Pueblo I sites*, four same of the unique *Rosa* type, and three as yet undetermined types of sites that will require laboratory research for their proper classification.

From time to time the Mohrs have transported jeep station-wagon loads of artifacts and other archeological materials to the Mesa Verde National Park Archeological Museum for storage. Included in their cargo are several scores of whole and restorable pottery vessels, many types of stone and bone tools, several human skeletal remains, and similar remains of two prehistoric Indian dogs (one perfectly preserved, a rarity which the Park Museum desires soon to place on exhibition). In addition, there is a considerable amount of important miscellaneous material of research interest. Owing to their great archeological interest, all material and related scientific records from San Juan Basin right-of-way will be permanently deposited, in accordance with my assignment, in the Mesa Verde Archeological Museum as a gift of Pacific Northwest Pipeline Corporation. This is logical as Mesa Verde National Park anticipates about 200,000 visitors this travel year.

Dr. Douglas Osborne, assistant professor of anthropology, University of Washington, at Seattle, and curator of anthropology of related Washington State Museum, has given notable cooperation in recruiting archeologists for field operations in the State of Washington. Due to the especial interest of the department and the museum in possessing the archeological material and records gathered in Washington, both will be permanently deposited with the Washington State Museum and accessioned as the gift of Pacific Northwest Pipeline Corporation.

Final reports on the findings are yet to come. Claude Warren, who supervised the salvage excavation of the Wenas Creek site near Yakima, will prepare a final report on his findings soon. Alan Bryan, graduate archeologist, will report on the Columbia Ridge site, and Donald Tuohy, his teammate on Washington and western Idaho right-of-way, will present a similar report on salvage excavation of the campsite near Battleground, Washington. They will also jointly report the results of their field operations within the extensive quarry site south of La Grande, Oregon.

Pipelining and archeology are strange teammates, but such cooperation on Pacific Northwest's pipe line system has, in synthesis, fortified and enhanced prior knowledge of human pre-history along the course of its pipe line and again demonstrated that commercial enterprise and archeology can each achieve cherished objectives through cooperative rescue of the archeological values that earthmoving construction threatens to destroy.

PACIFIC NORTHWEST PIPELINE PNW FEATURE

Operating the Pacific Northwest System

Arthur B. Allyne
Vice President of Operations
Pacific Northwest Pipeline Corporation

WITH the bulk of the 1955-1956 construction program completed, steps were taken this summer to form the operating group for the Pacific Northwest Pipeline system and to begin to place it in actual operation. By mid-August all facilities necessary to place the line in service up to the Oregon-Washington border were completed and customers began to be served by the line. It was thought advisable to start breaking in men, compressor stations, and other facilities along the southern part of the system as soon as possible prior to the larger loads coming on in the State of Washington later in the fall.

The general operating headquarters of the system was established in Salt Lake City the middle of August and necessary office space and other needed facilities acquired. Aside from the office functions of the usual pipe line company, such as sales, accounting, and legal departments, the physical operation of the system will be divided into two groups, namely, Production and Transmission.

The Production Department under **J. M. Clark,** vice president, will be responsible for Pacific's drilling program, geological work, and the operation of wells and gathering systems that will supply the transmission facilities.

The Transmission Group, under **Arthur B. Allyne,** vice president, will be responsible for the operation and maintenance of the processing plant at Ignacio, Colorado, main line compressor stations, gathering booster stations, meter stations, and all other portions of the pipe line system.

The pipe line itself will be divided, at least initially, into two divisions and will operate under the division manager plan. Division I will comprise the facilities located in the states of Utah, Colorado, Wyoming, and Idaho, while Division II will cover the states of Oregon and Washington.

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division will rest entirely in the hands of the division manager and assistant division manager. This responsibility will cover all activities within the division, including the pipe line, compressor stations and the like.

Under the vice president for transmission the general superintendent, **K. C. Biedermann,** will have overall supervision of the operation and maintenance of transmission facilities. He will be assisted for compressor stations by **M. A. Hardie** and his chief operating clerk will be **D. H. Sloan.**

Under the general superintendent all measurement activities will be under the supervision of **F. M. Partridge** and gas control and dispatching will be supervised by **W. C. Brady.**

There will be a number of measurement supervisors and meter inspectors located in the field, responsible to the measurement superintendent but under the guidance of the division manager for their day-to-day activities.

Although part of the gas dispatching group will be in Salt Lake City, a staff of dispatchers will be functioning at the process plant and Station I near Ignacio, Colorado, to relay instructions to plant superintendents and production personnel in the field, depending on load variations.

Communications will be by full-period, leased-line telephone circuits and VHF radio, at least during the initial phases of operation.

Working closely with the gas control supervisor will be the manager of production operations, **L. G. Truby,** who also will have his headquarters in Salt Lake City. As a large portion of Pacific's gas supply will be produced by Pacific or the wells operated by them, it will be necessary for the gas control supervisor and the production operating group to work in close harmony.

For operation and maintenance purposes the pipe line has been divided into 11 districts within the two divisions. Each of these districts will be under the guidance of a local superintendent and he will be responsible on the average for about 200 miles of pipe line. "Permanent operating headquarters along the line and the purchase and disbursement of heavy work equipment is being kept fluid until after the first winter's operation. This is felt advisable until sufficient operating experience is gained to dictate the proper amount and location of such facilities.

Contractual arrangements are also being worked out with outside contractors to supplement and assist our own pipe line maintenance crews and similar arrangements with machine shops within easy reach of our compressor stations.

Pacific will have a small fleet of its own airplanes and these will combine inter-company travel and aerial patrol up and down the lines at least for the first year of operations. Helicopters are being considered to assist in this work where terrain and weather conditions make the use of such equipment appear desirable, as well as possibly assisting in the collection of well charts and reading of meters in the San Juan Basin, Big Piney, Piceance Creek, and other fields.

Due to the high altitudes that we encounter it may be necessary to procure special snow equipment in order to gain access to our facilities in certain areas either during emergencies or in the routine work in our gathering systems.

Because of the great extent of the Pacific Northwest System, rough and sparse terrain, and severe weather conditions at times, we must place great responsibility on our field supervisory personnel. Further, we are traversing a virgin area with gas for the first time and feel it highly desirable to make friends with the people in the areas through which we pass. Accordingly, we have taken great pains in the selection of our key field people, paying particular attention to their ability to make friends, to command the respect of those under them, and who are willing to take responsibility and act accordingly when the occasion demands.

All of our compressor station and pipe line superintendents have come to us with years of experience behind them. Practically without exception they have proved themselves as employees of Fish Northwest Constructors during the construction phase of the project and we, therefore, feel we go into operations with a well-balanced and dependable team.

Pacific Northwest PL Officials

C. R. Williams

Stuart F. Silloway

Allen B. Hiatt

Robert R. Herring

C. R. Williams, vice chairman of the board, is a chemical engineer by training but a pipeliner of note in recent years. Williams has had wide experience in the oil and gas industry and is well known throughout the industry, making his role as a builder and organizer of Pacific Northwest Pipeline easier.

During 12 years with Continental Oil Company, Williams advanced to general manager of the oil and gas division. In 1942 he moved to The Chicago Corporation as vice president in charge of operations.

In 1951, Williams joined Pacific, serving as president until mid-1956. As president, Williams directed the activities of the growing pipe line firm during the formation and construction stages.

Stuart F. Silloway, president, has an extensive background in financing and organization of many oil and gas projects. As financial vice president of Mutual Life Insurance Company of New York, Silloway has had major positions of responsibility in formation of large projects. He has a broad and successful record with several New York investment groups. A science graduate and presently trustee of Wesleyan University, Silloway was named president of Pacific in July, 1956, to actively manage the affairs as the firm began operations.

Allen B. Hiatt, vice president, engineer, was a long time employee of Phillips Petroleum Company as head of the natural gasoline department, chief engineer, staff director of engineering, director of governmental regulations, and technical advisor. Hiatt has an outstanding background in natural gas, natural gasoline engineering, pipe line design, marketing survey, gas contracts, and sales.

Arthur B. Allyne, vice president of operations, has 30 years' experience in oil and gas work as research chemist for Shell Oil Company and later as chemical engineer with Southern Counties Gas Company. He joined the staff of the California Railroad Commission in 1937 and advanced to senior gas engineer.

Following World War II, he became gas consultant on the staff of Ebasco Services, Inc., responsible for numerous engineering and economic studies of gas transmission networks and distribution systems. During 1950-51, he served as project manager for the new gas system of the East Tennessee Natural Gas Company. After leaving Ebasco in 1951, he was named general manager of the Honolulu Gas Company, Ltd., and Pacific Refiners, Ltd., in the Hawaiian Islands. He joined the builders of the Pacific system near the beginning of the project and served as project engineer for Fish Northwest Constructors. He was named vice president of Pacific early in 1956.

Leon M. Payne, vice president and secretary, is an economist and lawyer with the law firm of Andrews, Kurth, Campbell and Bradley, Houston. He became associated with Pacific in 1951 during the formative and promotional years. Payne is also a vice president of Spokane Gas and Fuel Company, and assistant secretary of Fish Engineering and several other Fish enterprises.

Robert R. Herring, president of Fish Service and Management Corporation, was active during the formative and construction years of Pacific Northwest. Formerly a vice president of Pacific, Herring at the present time is a member of the board of directors. Fish Service and Management is engaged in engineering and construction services for several distributions systems to be served by Pacific.

Herring started in the oil and gas business in West Texas, and was general manager of an operation in that area. He joined the Fish interests in 1939 and since that time has served as assistant to the president of Fish Engineering. He has served as consultant to many natural gas transmission and distribution companies and has personally directed the engineering, design, and construction of numerous distribution systems.

PACIFIC NORTHWEST PIPELINE PNW FEATURE

Stations were designed for low temperature and high altitude operations with minimum personnel

Compressor Station Design and Construction

J. T. Cannan

General Manager,
Fish Engineering Corporation, Houston, Texas

EXTREMES of temperature and elevation on the new Pacific Northwest Pipeline Corporation's system required several modifications of conventional compressor station design. With nearly 1500 miles of natural gas pipe line through deserts and over mountain passes, nearly every possible operating condition can be encountered.

Pacific's unique two-way supply also had to be considered in designing the $204,000,000 system. With initial deliveries of gas to begin only 14 months after construction got under way, construction and design time were important factors.

Thirteen main line compressor stations on the Pacific Northwest system will supply a total of 82,780 compressor hp. The compressors will be located at varying intervals along the 1500 mile main line running from the San Juan Basin in Colorado and New Mexico to the international boundary near Sumas, Washington. Two booster stations with 5720 compressor hp have been installed to deliver gas from the Piceance Creek field in Colorado and the Big Piney field of Wyoming to the main line.

Winterizing

Special emphasis had to be paid to winterizing stations, as the geographical route passes through Colorado, Utah, Wyoming, Idaho, Oregon, and Washington. Because water along the route is comparatively scarce, all stations except Station No. 1 at Ignacio use air-cooling. Unitized design is an additional feature of all gas engine compressors on the main system.

Station No. 1, a 12,000-hp installation, the largest on the line, is situated on the northern limits of the San Juan Basin at Ignacio, Colorado. Gas will enter this station and then the main line after extraction of hydrocarbon liquids at the adjacent processing plant. *This gas plant will produce approximately 7000 bbl of light products per day when the system is in full operation.* Six 2000-hp compressors will compress the gas to 800-psi line pressure. Other main line stations vary from 4000 to 8000 hp each.

Of the 13 stations on the line, 11 are located more than 3000 ft above sea level and five of these are above 6000 ft. **In Wyoming near the Big Piney field, a 5060-hp station has been installed at the highest elevation, 7325 ft above sea level.**

The extreme altitudes required that a deration factor be included when siz-

The Author

J. T. Cannan was promoted to general manager of Fish Engineering Corporation last February. He has been with the company since 1948 and has served as project engineer on gasoline plants, oil black plants, dehydration plants, compressor stations, etc. Prior to joining Fish, he was a design engineer with Dow Chemical Company at Freeport, Texas, working on the design of magnesium cells, ethylene dichloride, and caustic plants. He graduated from Texas A & M in 1939. In World War II he was a lieutenant in the U. S. Navy.

Compressor station No. 1 at Ignacio, Colorado. Adjoining the station is a gasoline plant which will extract about 7000 bbl of light products daily.

ing the stations. Turbocharged engines, specified for high altitude operation, are derated following curves specified by the manufacturer. This deration is considerably less than that used for naturally aspirated engines. At 6000 ft the deration factor is 0.814, indicating 814 effective hp for every 1000 hp installed.

Unitized Design

All stations will be completely dependent on line gas for power under initial operating conditions. Gas engine driven generators will provide electric power for auxiliary services. Each gas engine driving a compressor will have power take-offs for its appurtenant equipment. This unitized design is typical of all stations except Station No. 1.

The unitized arrangement uses an individual hydraulic oil pump and motor to take power from the engine for driving the aerial cooler fan. Jacket-cooling water is circulated by a fan-driven engine-mounted pump. An automatic temperature control valve operating on the hydraulic oil bypass maintains predetermined water temperature although ambient air temperature may vary considerably. This control valve can vary the speed of the fan from 0 to 390 rpm, depending on engine cooling requirements.

The hydraulic oil pump, placed below the engine-room floor, is driven through a V-belt drive from the fly wheel of the engine. The fan, in turn, is driven by a hydraulic motor through a right-angle gear speed reducer.

Cooling Water System

Each engine is equipped with a combination jacket-water and lube oil cooling water system in order to simplify operation and control.

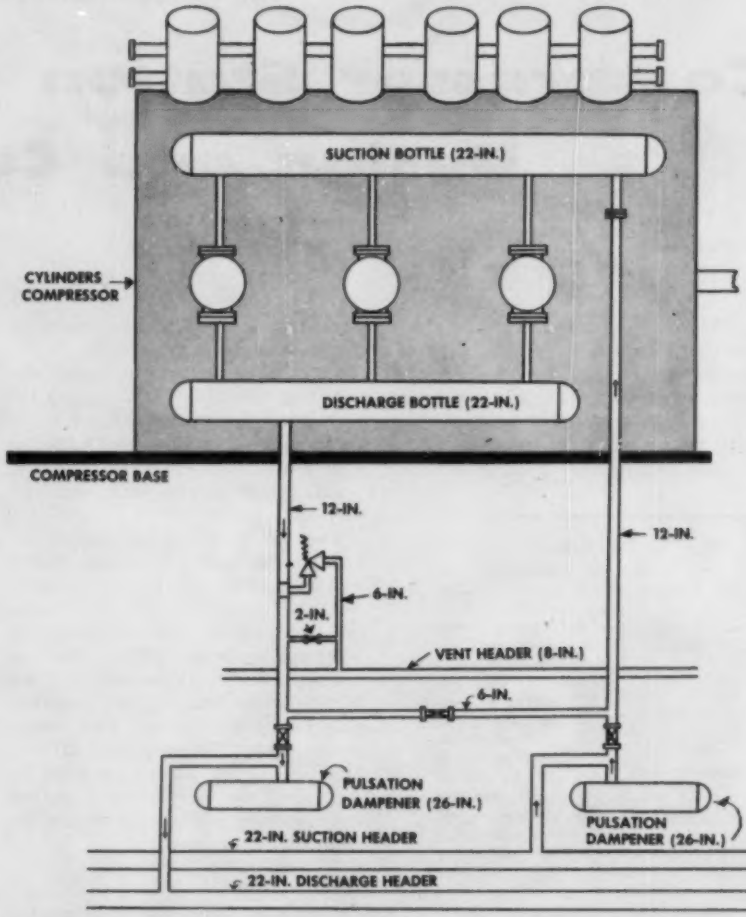
The desired operating temperature is obtained in the combined system by utilizing the principle of mixing hot water from the engine jackets with colder water from the aerial cooler. A portion of the 170F hot water from the engine jacket is bypassed to the aerial cooler where it is cooled to 120F. The cold water then flows to the lube oil cooler with side stream going to the turbo-intercooler. The turbo-intercooler water temperature is controlled by an automatic temperature valve on the engine.

A hot oil bypass is provided on the oil cooler, automatically controlled by a three-way temperature regulating valve.

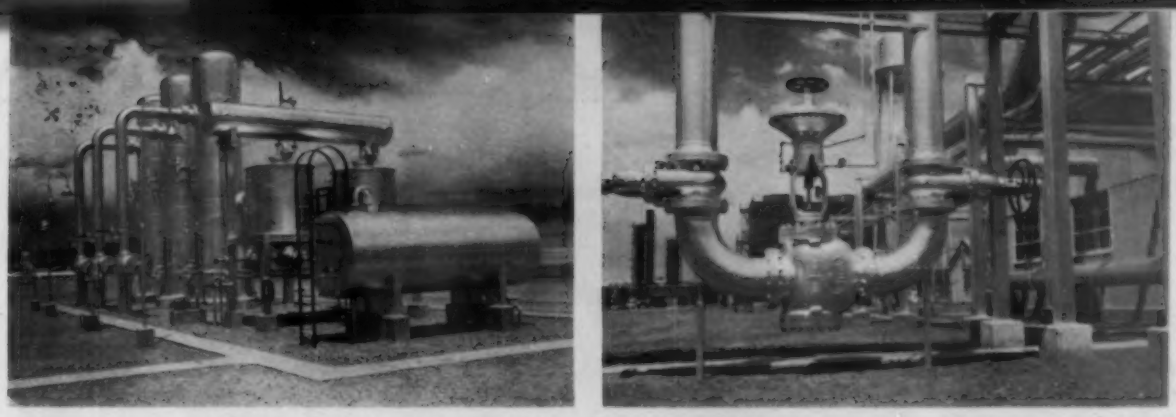
The main stream cooling water leaves the lube oil cooler at 145F and mixes with the 170F water from the hot water bypass and enters the engine jackets at a predetermined temperature of 160F.

The hot water leaving the engine jackets flows to an individual surge tank inside the building where it is picked up by the jacket-water pump on the engine and discharged to the aerial cooler situated outside the building to complete the water flow cycle.

Manual adjustment of the compressor jacket-water temperature regulating valve can attain additional flexibility



Compressor piping arrangement showing location of suction bottles, pulsation dampeners, venting arrangement, and manifolding with suction and discharge headers.



Dust scrubbers (left) and jacket water temperature control valve (right) at Station No. 1.

and control of a jacket-water temperature when extreme fluctuations of ambient temperatures occur.

In this cooling system, engine jacket-water can be maintained at a constant temperature, closely following the cooling requirements of the engine. Unnecessary cooling at start-ups and during cold weather are eliminated.

Low Temperature Precautions

Special precautions had to be taken in station design to overcome the extreme cold weather conditions along the route of the line. Precautions as simple as placing jacket-water coolers on the south side of the compressor building are used. The low temperatures prevailing throughout the winter require extra effort to avoid any hydrate formation. Gas will be handled at a much lower dew point than that used in more temperate areas. Special solid desiccant type dehydrators designed by Fish Engineering Corporation have been installed on all of Pacific's gas wells. These dehydrators have been thoroughly tested at low temperatures and have consistently provided safe dew point depression.

Glycol pumps will inject anti-freeze solution into the cooling system as needed from summer storage in the compressor building. All water lines will be buried below the frost line, which extends quite deep in some locations. Freeze boxes—insulated wooden frames — will protect meters and instruments installed outside of buildings to prevent direct exposure to the elements.

Every meter or other installation that is subject to freezing or poor operation in cold weather has been housed. Each compressor building includes a basement, that provides additional protection areas at the station. A lube oil reservoir situated in each engine building will have a capacity sufficient to supply two engines, providing warm oil even in extreme conditions. Jacket-water surge tanks and starting air tanks also will be housed.

The gas stream leaving the station is not cooled due to the generally low ground temperature along the route. Station No. 1 at Ignacio, Colorado, is the lone exception. Discharge lines at each station will extend from the compressor building on concrete piers with expansion provided to the main line.

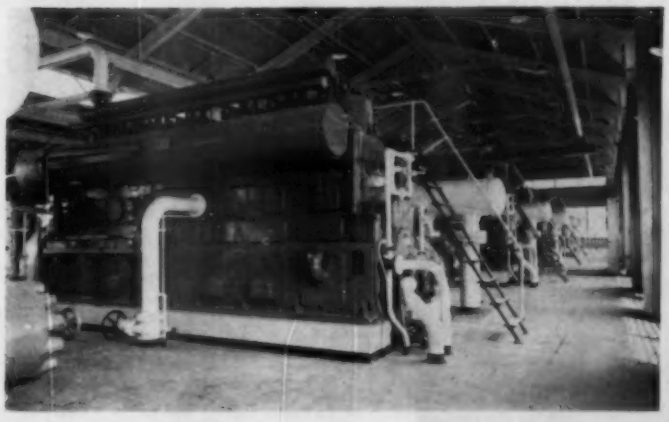
Shutdown System

The general recommendations of the Oil Insurance Association of ASA for natural gas pumping stations have been followed in designing the emergency station shutdown system. The shutdown system operates on gas pressure and is designed to positively accomplish the following related acts:

1. **Stop all compressor engines by ignition cutout or grounding and fuel cutoff.**
2. **Actuate power closing of the gas suction and discharge station side gates to stop all gas flow into the station. The mainline bypass valve, to permit continued flow of gas in the main line, will be manually operated when mainline pressures upstream and downstream of the station are equalized.**
3. **Release all station-contained gas volume and pressure through the power opening of the blowdown valves.**
4. **Extinguish all open-flame-fire devices when escaping gas might possibly be ignited and open all electrical circuits.**

General Features

High compression ratio engines, up

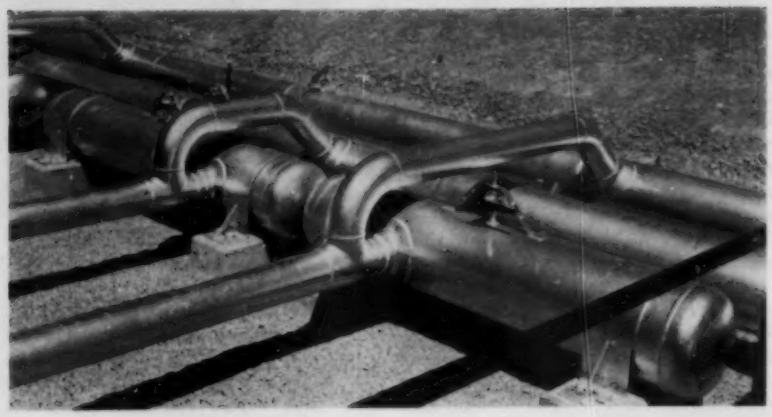


Inside compressor building, Station No. 1.

Compressor building basement.

Compressor station at Kemmerer, Wyoming, is 4500-hp main line installation.

Pulsation dampener bottles on suction and discharge lines at Kemmerer station.



to 2.0, were installed to take advantage of compactness and higher efficiency. Close attention was paid to station piping as pressure drop of 1 psi is equivalent to about 40 hp. Gas scrubbers, connecting piping and valves, were carefully sized to minimize the total pressure drop.

The high pressure system utilized full-opening welded-end valves throughout. With the exception of water lines, all piping will be above ground on supporting structures to eliminate trenching, doping, and to makes lines readily accessible. Oil bath scrubbers of wide capacity and wide range for removable particles were selected for use on the system.

Unusual Manifold Arrangement

An unusual piping-manifold arrangement has been installed at Station No. 14. This station is near Umatilla, Oregon, at the junction of the main line from the south, the main line continuing to the Canadian border, the Spokane lateral, and the Wenatchee lateral. Four 1000-hp compressors have been installed at this station. Unusual flexibility has been provided since it will be possible for gas to enter the station from the south and be pumped north, from the north and pumped south, or taken from both directions on the main line and pumped to the Spokane and Wenatchee laterals.

The Pacific Northwest line system is unusual in several respects. As the first major transmission line designed to be supplied from both ends, unusual operating flexibility results. Pacific's system will have an operating maximum day capacity of 696,000,000 cu ft of gas per day with mainline diameter of 26 in.

Rather than the usual funnel system, Pacific can better be described as hourglass in appearance with 26-in. diam line on the north and south and 22-in. in the center of the system.

During initial operation of the system, all gas for the Northwest will be supplied from the fields in the San Juan Basin and the Rocky Mountain areas, for a maximum daily total of 393,000,000 cu ft. Late in 1957 an additional 303,000,000 cu ft per day will be delivered from the Peace River field of Alberta and British Columbia through the lines of the Westcoast Transmission Company to the international boundary near Sumas, Washington. At this point, Pacific will pick up the additional load and deliver it largely to markets in the State of Washington. This two-way supply along with compressor station design will assure uninterrupted service for Pacific's distribution companies at any point on the system.

Fish Engineering Corporation handled all of the design, engineering, and station layout work, while Fish Northwest Constructors, Inc., are responsible for construction of the stations, acting as direct agents for Pacific Northwest Pipeline Corporation.

Inside the compressor building at Kemmerer.

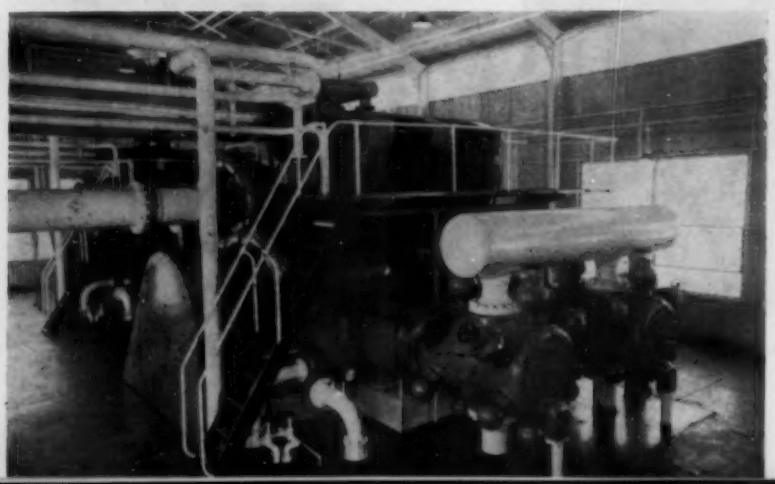


TABLE 1.
Pacific Northwest Compressor Stations

Station	Station compressor hp	Altitude, ft
Station 1	12,000	6600
Station 2	8000	5620
Station 4	8000	6000
Station 6	6000	6120
Station 7	4500	6300
Station 8	6000	4440
Station 9	6000	3000
Station 10	5280	3000
Station 11	6060	3000
Station 12	4500	3000
Station 13	4500	3000
Station 14	4000	1000
Station 18	8000	1000
Field Boosters		
23 (Big Piney)	5060	7325
24 (Picesance)	660	6250

* * *

Tandemed Clevelands set the pace on tough 78-mile line in North Carolina

PUSHING A 78-MILE NATURAL GAS LINE from Chapel Hill to Sanford, North Carolina, J. A. Jones Construction Co. of Charlotte used two Clevelands in tandem to set the pace on a tough construction job. The lead trencher, a Cleveland 95, opened up an initial cut to a depth of 2 feet. The second machine, a Cleveland 110, then dug the trench down to finished grade, an average of 3½ feet deep. Each cut was 18 inches wide.

Boulders, rock outcroppings and closely spaced culverts cut across the trench line every few feet. Rock blasting was required frequently with each shot covered by a heavy dragline mat. Three rock drilling crews were kept busy most of the time. In spite of the difficulties encountered, the job moved forward at the rate of a mile a day or better—trench dug, pipe joined and laid, and backfilling completed.

Good Everywhere

THE CLEVELAND TRENCHER COMPANY

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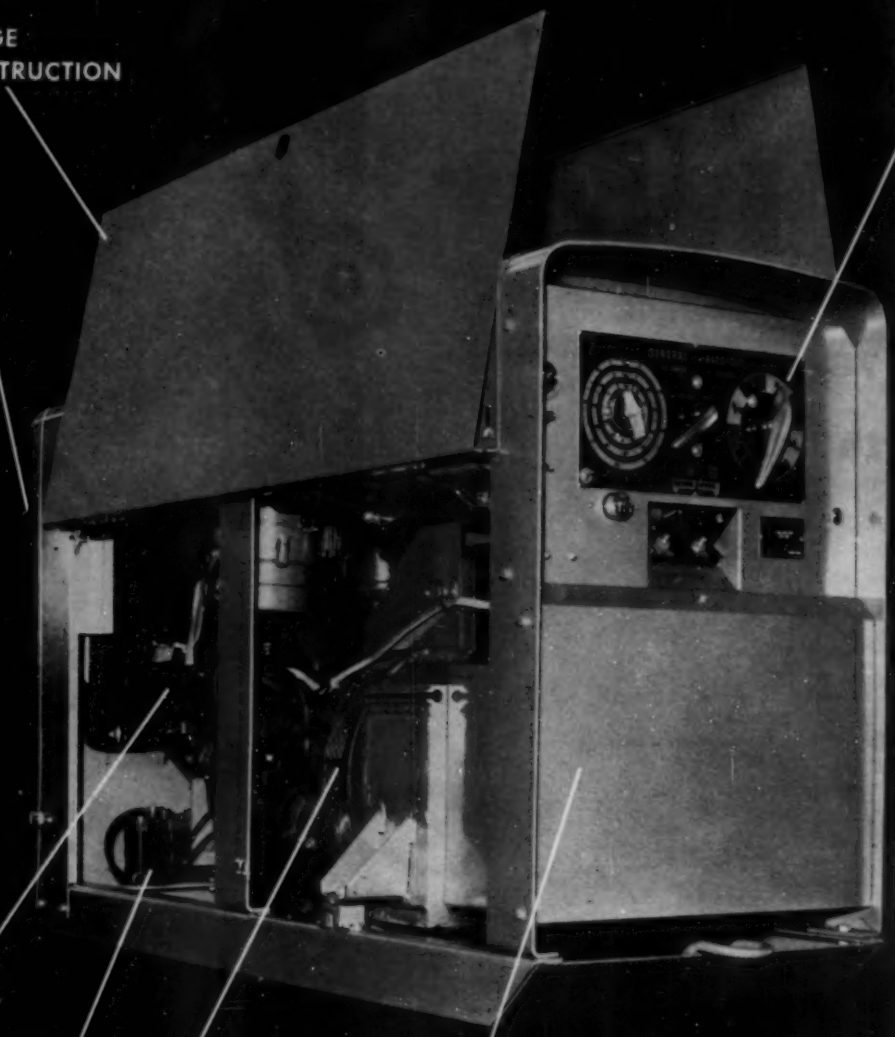

Prove it to yourself— Make this actual feature-by-feature comparison of General Electric engine-driven welders with two other lines of engine-driven welders. You will see that only the new G-E welders have so many advanced design features for better welding at lower cost.

EASILY PRESET Electrode Selector, Current Dial—Dual controls make current setting easier and more accurate.

GENERAL ELECTRIC	✓	
MANUFACTURER A		
MANUFACTURER B		

NOW—AVAILABLE IN 200-, 300-, 400-AMP MODELS

How General Electric's NEW Line of Engine-driven Welders Can Help You Meet Contract Deadlines

Advanced design assures less "downtime," minimum maintenance— for faster, lower-cost welding

Nothing stretches out construction time more than unreliable or obsolete equipment. Such equipment increases your maintenance costs and results in nonproductive "downtime." It may even lead to contract fines and loss of repeat business.

To reduce construction delays, General Electric's new line of engine-driven welders has been designed and field-tested for maximum durability and minimum maintenance—without sacrifice in performance. These new 200-, 300-, and 400-amp welders save for you with the following advantages:

SAVE YOU TIME—Sturdy construction, the dependable Hercules engine, new-design generator, and simplified control all combine to give you steady output, longer operating time between overhauls, and reduced maintenance. This means more production per machine . . . per man-hour.

SAVE YOU MONEY—General Electric engine-driven welders begin saving you money the first day on the job. For example, the deep-sump crankcase provides complete lubrication to all moving engine parts—up to a 15-degree tilt in any direction. This helps to reduce costly breakdowns. And the over-all advanced design assures you of more and better welds at less cost, with a reduction in costly downtime for maintenance and repair. Additional General Electric advantages are described below.

For more information about how General Electric engine-driven welders can help you, contact your nearby General Electric Welding Distributor. He is listed in the yellow pages of your telephone book. Write for descriptive bulletin to Section 714-5, General Electric Company, Schenectady 5, New York.

Progress Is Our Most Important Product

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CONSTANT-PRESSURE Brush Springs—Right pressure maintained for life of generator brushes without adjustment.

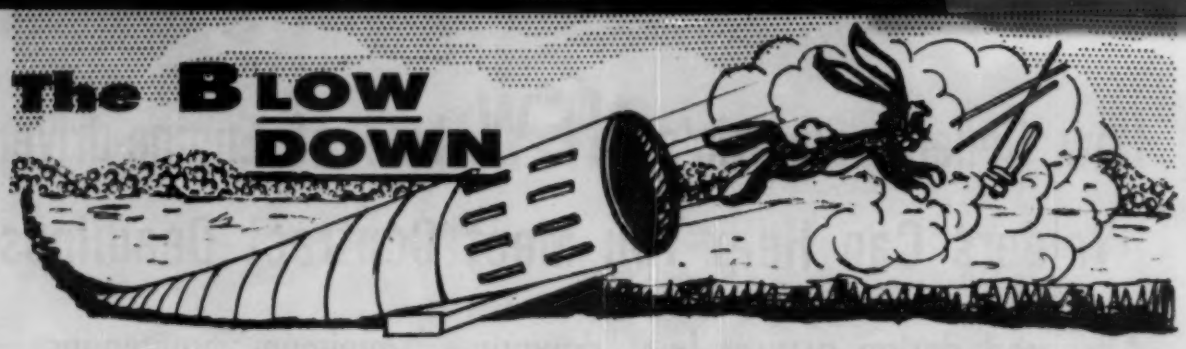
PRELUBRICATED Generator Bearings—Ball bearings prelubricated with sufficient grease for years of service.

DEPENDABLE Geared Governor—Gear-driven governor maintains close speed regulation for best welding.

PUSHER-TYPE Engine Fan—Large diameter pusher-type fan circulates ample cooling air for engine and generator.

CONTROLLED CURRENT Peaks—Current peaks are controlled. Arc can be crowded with no "stumbling" or "freezing."

	✓	✓	✓	✓	✓
		✓	✓	✓	
				✓	



News from the Field and Plant about People you know

PROFILE OF A PROJECT PUSHER

One day when the battle for Pacific Northwest's certificate of convenience and necessity was raging before FPC, Leon Payne got a long-distance call in Fish Engineering's Houston office. R. D. Ricketts was calling from Washington, D. C.

"Come on up here, Leon," said Ricketts. "We need you."

"Sure, Dick. First thing in the morning."

"Why not now?" asked Ricketts. "It's only 2:30 your time; you can catch the 3:30 plane and be up here in 5 hr."

"But Dick, I'm wearing a sport shirt, and I don't even have a coat at the office — much less a toothbrush," protested Payne.

"Come on anyway. I'll let you borrow a coat and you can buy a toothbrush. You'll be here only a day or two," promised Ricketts.

Payne called his wife. "See you in a day or two," he said, and took off for the airport on the run.

It was three months before he got back to Houston.

To Ricketts, president of Fish Northwest Constructors, time and money are interchangeable commodities — equally valuable. If he has a slogan it is: "Why not now?" Perhaps this explains how his company engineered, designed, and constructed the Pacific Northwest system with such remarkable speed. He feels that if there's a job to be done, the faster it's done, usually the better. For this reason, he has a reputation of being something of a slave driver in his own company. But everyone with Fish Constructors will point out that he drives himself hardest of all.

On a typical day during the construction of the line (which was completed and operating in slightly more than 14 months) Ricketts probably averaged working something like 12 to 14 hr a day. When he had to fly from one office or from one job to another, he usually did it at night to save time. And even in the company plane, he worked. He seems to get great personal satisfaction out of doubling up on the clock.

Trailing along with him, even after he left the office, was like being caught up in a whirlwind. Once, I* was elected to take him to the Salt Lake City airport so he could catch his company plane. He had a 9:30 flight that night in Denver, and it was after 6:00 p.m. when we got away from his office in Salt Lake. On the way to the hotel, he kept up a running fire of instructions to his assistant Vann Kerns, and continued this while packing his luggage at a furious clip in the suite he maintains there. When he finished his packing, he looked up.

"Call the bell boy," he said and strode to the wash basin and washed out a pair of socks in the time it took the bellhop to get to the room. When I asked him later why he performed such a menial task, he said: "Menial, hell! The hotel laundry charges 20 cents a pair for socks and I can wash 'em out in 30 seconds. When I do it I'm working at the rate of $24 an hour! Besides, the laundry ruins the elastic in the top."

Ricketts delights in doubling up on **time.** On the way to the airport he disposed of a conference. At the plane, he swallowed a pill to prevent airsickness, slid into his seat, opened a brief case and began working before the pilot got his luggage on board.

He even combines pleasure with business to squeeze the most out of the clock. He can play a vicious game of gin rummy and work at the same time. One night about 11:00 he got a long distance call just as the cards were dealt. He continued playing, drawing and discarding skillfully, as he talked over a particularly knotty problem with one of his men in Spokane. Finally, he slapped his cards on the table, "gin"; and continued his telephone conversation. The men he played with were used to such oddities and thought little of the incident.

Along with engineering experience, Ricketts has had quite a bit of sales experience, too. At times he can be very persuasive. Once when contractor Jim Fulghum was bemoaning the difficulties of the Columbia River crossing where boulders in the river bed are large as houses and the water is as swift as almost any stream in the country, Ricketts sought to reassure him.

Fulghum listened as Ricketts described the ease with which the task could be accomplished. Finally, Fulghum exclaimed, "Hell, to hear you talk Dick, all I need to cross this river is a straw hat and a row boat. I can dredge the ditch with the straw hat and lay the pipe with the row boat!"

*Don Taylor, Gulf Coast Editor, The Pipeline Engineer.

Gin rummy game in the Multnomah Hotel in Portland, Oregon. R. D. Ricketts, facing camera, Vann Kerns, left, Al Fiddler, upper right, and J. W. Hall, right, relax after 14-hr day. Men put 10 hr work in Salt Lake City office before flying to Portland for more conferences and decisions.

Push-button selector speeds coded data in Gulf Interstate's telemetering system

You are looking at a special push-button private line teletypewriter device developed by the Bell System and used by Gulf Interstate Gas Co.

The company uses the teletypewriter as a recorder in its digital telemetering system, which provides automatic transmission of operating data. Such data includes engine speeds as well as suction and discharge pressures at five remote compressor stations.

The dispatcher in the company's Houston headquarters simply pushes the proper buttons. The selected distant station is instantly on the circuit. Coded telemetered data is then received directly on the teletypewriter in the form of an accurate, easily read record.

This unique selector unit is another example of how equipment developed by the Bell System meets communication needs.

The Bell System welcomes the opportunity to work with you in a study of your special communication requirements. There's no obligation.

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PRIVATE LINE TELEPHONE · PRIVATE LINE TELETYPEWRITER
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The Pipeline Engineer's

1956-57 Pipe Line Contractors Directory

Here is an up-to-date listing of both general and specialized pipe line contracting companies. Given are the firm names, addresses, telephone numbers, and chief contact in each company, as furnished by the companies themselves. The first pages list firms that do general pipe line contracting. Specialized firms are listed on the following pages.

A. B. C. Construction Co., Inc.
12420 South Bellmfield Avenue
Norwalk, California

A & A Construction Company
3720 West Broadway
Box 1597
Muskogee, Oklahoma

Aldridge-Peage, Inc.
1091 Manchester Street
Lexington, Kentucky

E. K. Aldridge & Sons, Inc.
Box 1324
Athens, Georgia

Altgelt Construction Co., Inc.
3502 Lawrence Drive
Box 1402
Corpus Christi, Texas

B & M Construction Company
2808 First Natl. Bldg.
Oklahoma City, Oklahoma

Banister Construction, Ltd.
625 Northern Hardware Building
Edmonton, Alberta, Canada

Barry Construction Co.
4108 Old Spanish Trail
Houston, Texas

C. P. Bartley & Son
Box 616
Tioga, North Dakota
Phone: 4-2214
C. P. Bartley, Sr., President

Baughman Contracting Co., Inc.
Rt. 1, Box 569
Cumberland, Maryland

Bechtel Corporation
220 Bush Street
San Francisco 4, California

O. O. Berryhill
Box 3277
Temple, Texas

Briner Rust Proofing Co., Inc.
Box 984
Albuquerque, New Mexico

Brown & Root, Inc.
4100 Clinton Drive
Box 3
Houston, Texas
Phone: FAirfax 3-7121
L. E. Minor, Mgr. P/L Dept.

O. R. Burden Construction Corp.
6702 East 21st Street
Box 5216
Tulsa, Oklahoma
Phone: TEmple 8-3378
O. R. Burden, President

Burkhardt Construction Company
Box 160
Vermilion, Ohio

C & R Constructors, Inc.

C. Hubert Gragg Construction Co.
223 Britton Road
Oklahoma City 14, Oklahoma

Campbell P & H Company
958 Kentucky Street
Mobile, Alabama

Canadian Bechtel, Ltd.
25 King Street West
Toronto, Ontario, Canada

Chambliss-Kirksey, Inc.
Box 289
Sweeny, Texas

W. E. Claycomb and Son
Route 1
Cody, Wyoming

Comstock, Ltd.
206 Laird Drive
Comstock Building
Toronto, Ontario, Canada

Consolidated Construction Co.
Box 505
Carthage, Texas

Consolidated Gas & Serv. Co.
327 LaSalle Street
Chicago 4, Illinois
J. C. Donnelly, President

Construction Service Co.
Lincoln Blvd. at Cedar
Box 311
Bound Brook, New Jersey
J. J. Senesy, President

Constructora El Aguila, S.A.
Reforma 30
Mexico, D. F.
Mariano Silva S.

Contracting & Material Co.
1235 Dodge Avenue
Evanston, Illinois
Phone: Rogers Park 4-1294
W. P. Cagney, Jr., President

Conner Construction Co.
Box 1047
Odessa, Texas
Jack A. Conner, Owner

Conyes Construction Corp.
13685 San Pablo Avenue
San Pablo, California

R. L. Coolsaet Construction Co.
7600 Middlesex Avenue
Dearborn, Michigan

A. J. Curtis Construction Co.
Box 2009
Casper, Wyoming

Davis & Armentrout Construction Co.
Box 785
Pulaski, Virginia

B. J. Davis Construction Co.
Box 117
Ashland City, Tennessee

George W. Davis Construction Company
1414 N. Eastern
Box 186
Oklahoma City, Oklahoma

Donaldson Construction Co.
Dodge Center, Minnesota

Dutton-Williams Brothers, Ltd.
Pacific Building
Calgary, Alberta, Canada
Phone: 69-2669
M. A. Dutton, President

East Penn Construction Co.
Lancaster County
Landisville, Pennsylvania

Eastern Pipe Line Contractors
820 Mercantile Building
Dallas, Texas
Phone: Riverside 4081

A. J. Ellis Construction Co.
5555 Branchville Road
Box 98
College Park, Maryland
A. James Ellis, President

Engineering-Construction Co.
1st National Building
Tulsa, Oklahoma

Engineers Limited Pipeline Co.
225 Bush Street (General Office)
San Francisco 4, California
Phone: GArfield 1-2980

Eubanks & Smith Pipeline Construction Company
Rt. 2, Box 470
Greenville, Mississippi

John D. Fahey and Son, Inc.
1st Natl. Bank & Trust Bldg.
Waynesburg, Pennsylvania

L. E. Farley, Inc.
5717 Kirby Drive
Box 6841
Houston 5, Texas

Ferguson Construction Co.
Box 127
Eunice, New Mexico

Fish Pipe Line Construction Co.
796 M & M Building
Box 2617
Houston, Texas

Fisher Contracting Company
2201 S. 19th Ave.
Box 6306
Phoenix, Arizona

C. N. Flagg & Company, Inc.
79 Griswold Street
Meriden, Connecticut

Foran Construction Co.
500 Parker Street
Box 1865
Amarillo, Texas

Fowler-Tatom Pipeline Contractor, Inc.
Box 368
Cotton Valley, Louisiana

Fulghum Contracting Corp.
Box 1181
Harrisburg, Pennsylvania

R. H. Fulton & Company
Box 1526
Lubbock, Texas

Fulton-Banister, Ltd.
625 Northern Hardware Bldg.
Edmonton, Alberta, Canada

Gaesch Construction Co.
Box 386
Brownfield, Texas

General Construction Co.
Box 195
Clendenin, West Virginia

Geneva Construction Co.
111 Downer Place
Aurora, Illinois

H. L. Gentry Construction Co.
921 East Michigan
Jackson, Michigan

George Consolidated
7225 Culmore
Houston, Texas

The Pipeline Engineer's Pipe Line Contractors Directory . . .

Golightly Construction Corp.
6450 Liberty Road
P. O. Box 15243
Houston, Texas
Phone ORchard 2-0561
W. L. Golightly, President

Grayco Constructors, Inc.
1211 West 34th Street
Box 4147
Austin, Texas
Phone: HOmestead 5-8797
Jack S. Gray, President

Gray-Morrison Contractors, Inc.
Box 4086
Austin, Texas
Phone: HOmestead 5-8797
Jack S. Gray, President

G. G. Griffis, Inc.
4450 East Admiral Place
Tulsa, Oklahoma

Gustine Construction Co.
603 West Main
Box 1871
Ardmore, Oklahoma
Phone: 5963

The Hallen Co., Inc.
45-30 37th Street
Long Island City 1, New York

Hallmac Construction Co.
3701 Buffalo Drive
Houston 19, Texas
Phone: JAckson 2-2445
James W. Hall, President

Harbert Construction Corp.
Box 1369
Birmingham, Alabama

Harrelson Construction & Welding Co.
Box 432
Seymour, Connecticut

Henson Construction Co.
Box 1205
Cisco, Texas

Henuset Bros., Ltd.
Box 657
Virden, Manitoba, Canada

Herbert Bros. Engineers
Box 448
Plaquemine, Louisiana

A. C. Holder Construction Co., Inc.
1712 East Fifth Street
Box 3297, Whittier Station
Tulsa, Oklahoma

Hood Construction Co.
3002 East Century Boulevard
Lynwood, California
Phone: NEvada 6-1867

Houston Contracting Co.
2707 Ferndale Place
Houston 6, Texas

M. L. Hulcher Co., Inc.
Box 168
Virden, Illinois

E. A. Irish, Contractor
2944 Glenendon Street
Los Angeles 39, California

J. A. Jones Construction Co.
Box 996
Charlotte 1, North Carolina

Roy L. Johnson Construction Co.
Box 484
Eldorado, Kansas

Joyce Pipeline Co.
Box 385
Andover, New York

K-F-B Construction Corp.
Box 1775
Shreveport, Louisiana

KLW Pipe Line Construction Co.
607 State Life Building
Indianapolis 4, Indiana
A. A. Kalo, Gen. Mgr.

Keiller Contracting Co.
Box 84
Ancaster, Ontario, Canada

Kenton Meadows Co., Inc.
Box 518
Gassaway, West Virginia

The Kuljian Corp.
1200 North Broad Street
Philadelphia 21, Pennsylvania

Laurel Ridge Construction Co.
234 W. Pittsburgh Street
Greensburg, Pennsylvania

I. C. Little Contractor
Fidelity Union Life Bldg.
Dallas, Texas

Lone Star Constructors
10301 Shady Trail
Box 13167
Dallas 20, Texas
Phone: FLeetwood 7-2833
Paul R. Halbert, Partner
N. K. McFarland, Partner

W. M. Lyles Company
Box 495
Avenal, California
Phone: AVenal 222
W. M. Lyles, President

M. G. M. Construction Co.
Box 1056
Concord, California

M-R Company
Box 484
Wichita, Kansas

Macco Corporation
14409 South Paramount Blvd.
Paramount, California

Mannix, Ltd.
332 Seventh Avenue West
Calgary, Alberta, Canada
Phone: Calgary 6-7361
F. C. Mannix, President

Marine Pipeline & Dredging, Ltd.
640 West Hastings Street
Vancouver, British Columbia, Canada

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PRODUCT LINES
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Pipeline Cleaners Co.
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WALKER COMBINATION
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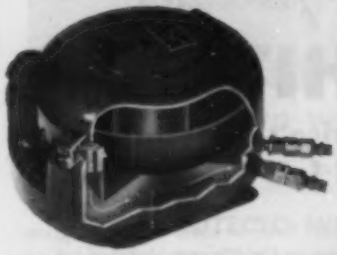

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Sharman, Allen, Gay & Taylor, Inc.
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Sheehan Pipe Line Construction Co.
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Box 255
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John C. Bayless, Oil Industry Mgr.
Aerial Surveys

American Dewatering Corp.
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River Crossing Dewatering
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Marine Dredging

C. F. Bean Contractor
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Marine Dredging

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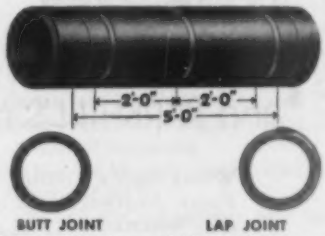

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Coating & Wrapping

Pipe Line Service Corp.
Box 318
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Coating and Wrapping

Pipeline X-Ray Service
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Box 6886
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Phone: MOhawk 7-5621
C. W. Radcliff, President
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R. S. Perkins
Welding

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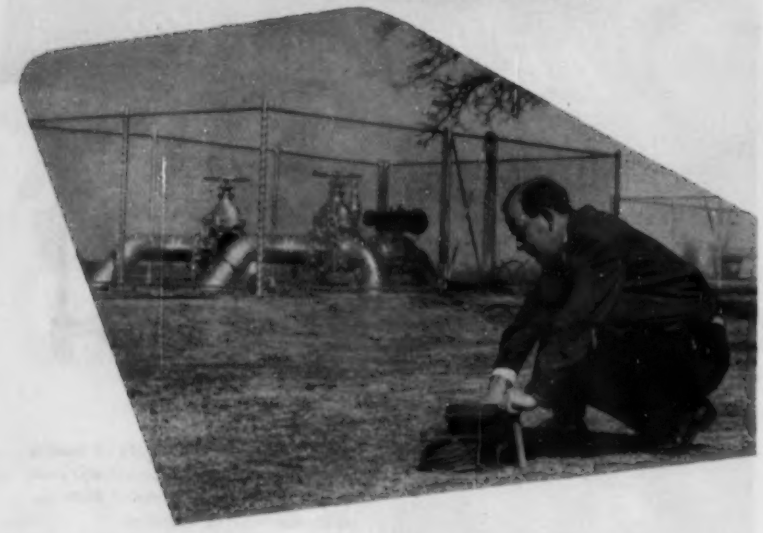

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Aerial view of the underground crossing of the San Juan River. After this section of the crossing was covered, the river was diverted over it and the crossing completed.

Construction Report

P 623.

El Paso Natural Continues to Expand

In constant growth for past decade, company's present program will increase deliveries by 750,000,000 cu ft a day

Marshall Willis
El Paso Natural Gas Company

YOU have to work hard to keep up with California and the Southwest.

Population of the area that El Paso Natural Gas Company serves (West Texas, New Mexico, Arizona, Nevada, California, and northern Mexico) is increasing by more than 500,000 people per year. The rate of increase of population is three times greater than the national average. New industries are moving in; established industries are producing more and more goods. The area and its economy are growing at a rate that is unprecedented. There is a constantly growing need for more and more natural gas service.

At the same time, natural gas reserves in California —upon which the state has drawn for many years — are declining. It is necessary, therefore, not only to expand gas service to meet growing public demand, but to replace the decreasing supplies of gas produced on the West Coast.

To meet this situation, El Paso Natural Gas Company has been engaged in constant expansion for the past decade. At the end of 1945, the company had 1957 miles of mainline and 208 miles of field line in operation. At the end of 1955, it had 6300 miles of mainline and 3800 miles of field and gathering lines in operation. In 1945,

Construction in progress on a 34-in. pipe line of El Paso Natural.

the company had a peak day sales of 152,410,000 cu ft per day. At present, the company has in various stages of planning and execution expansion programs that will increase mainline deliveries by 750,000,000 cu ft per day. At the conclusion of such expansion, El Paso Natural Gas Company will have sales of 2,838,000,000 cu ft per day, including intrastate sales of 200,000,000 cu ft. These figures do not include gas handled on an exchange basis with other pipe line companies nor the deliveries by an affiliated company, Utah Natural Gas Company.

The 750,000,000 cu ft per day of expansion is broken down into three parts:

(1) **An increase of 450,000,000 cu ft per day for which the Federal Power Commission has granted a Certificate of Public Convenience and Necessity.**

(2) **An increase of 150,000,000 cu ft per day for which an application is pending before the FPC.**

(3) **An increase of 150,000,000 per day upon which agreements have been reached but upon which plans have not been completed nor applications filed with the FPC.**

The expansion that is now in progress — the increase of system capacity by 450,000,000 cu ft per day—should be reflected in gas deliveries in the early part of 1957. The principal pipe lines to be constructed under the program are 338 miles of 34-in. pipe line paralleling the greater portion of the existing 24-in. and 30-in. pipe lines from the San Juan Basin in northwestern New Mexico to the Colorado River near Topock, Arizona, and 149 miles of 20-in. pipe line to be constructed south from a point near Williams, Arizona, to Phoenix. There will be added to the company's compressor facilities 60,430 hp (42,000 in mainline stations and 18,430 in field stations) to give the company a total of 758,645 hp. Field pipe lines to be built include 34.1 miles of 24-in. line, 42.4 miles of 20-in. line, and 36.3 miles of 12¾-in. line.

Thirty-four-inch pipe line being covered with rock-shield before being lowered into ditch on the San Juan River underground crossing.

The gas supplies for the additional 450,000,000 cu ft per day will be obtained from various sources: 250,000,000 cu ft a day are to be provided from the company-owned reserves and through purchases of gas in the San Juan Basin; 100,000,000 cu ft a day will be obtained from various sources of supply in the Permian Basin; 50,000,000 cu ft a day will be purchased from Pacific Northwest Pipeline Corporation at a point just south of the United States-Canadian border and immediately delivered by the company to Pacific Northwest in exchange for a like volume of gas in the San Juan Basin. Ultimately, it is planned that the remaining 50,000,000 cu ft of gas a day required for the project will be produced from the Pinedale structure in Wyoming, which is now under development by El Paso Natural Gas Company. This 50,000,000 cu ft will be delivered by the company to Pacific Northwest at a point in the Big Piney field in southwestern Wyoming, likewise in exchange for the delivery of the same volume of gas by Pacific Northwest to the company in the San Juan Basin.

As the Pinedale structure in Wyoming is still in process of development, with only limited well deliverability data available, the facilities proposed for the gathering and transportation of gas have not yet been authorized. Pending such authorization, the volume of gas scheduled to be taken from the Pinedale structure will be drawn from El Paso Natural's other sources of supply.

The 20-in. pipe line that is to be constructed from a point near Williams, Arizona, south to branch line facilities in the Phoenix area will be of much value to the company in integrating northern and southern pipe line systems. As is generally known throughout the industry, El Paso Natural's supplies of gas in the Permian Basin are predominantly residue gas (gas produced in conjunction with the production of oil.) The supplies of residue gas are subject to wide hourly, daily, weekly, and monthly fluctuations, which have to be absorbed, in part, by increased or decreased production in the San Juan Basin. This 20-in. pipe line will provide a great deal of flexibility in meeting these fluctuations. The pipe line also will be of great value in the event of a major interruption in operations in either the northern or southern pipe line systems.

Field compressor horsepower will be increased as follows: 10,800 hp additional at the now-existing Blanco Compressor Station in the San Juan Basin;

Ditching machine in operation on right-of-way near Flagstaff, Arizona.

Laying a 14-in. field line in the Permian Basin. This line links El Paso's Tex-Harvey plant with the Jameson pool.

2700 hp additional at the now-existing McElroy-Crane plant in the Permian Basin; 4050 hp at a new station near Pampa, Texas; 880 hp additional in the now-existing Tex-Harvey Compressor Station.

Dehydration capacity will be increased by 290,000,000 cu ft a day at the already existing Blanco plant and by 39,000,000 cu ft a day at the new Pampa plant. The McElroy-Crane plant of the company will be increased in treating capacity by 12,746,000 cu ft a day.

Mainline compressor power will be increased as follows: 6000 additional hp in the existing Gallup Compressor Station; 10,000 additional hp in the existing Navajo Compressor Station; 8000 additional hp in the existing Leupp Compressor Station; 8000 additional hp in the existing Williams Compressor Station; 5000 hp in the new Belen Centrifugal Compressor Station; 5000 hp in the new Caprock Centrifugal Compressor Station.

Construction of the facilities authorized is just getting well underway at this time. Two problems have been met and solved, however. Both involved water crossings, one the San Juan River and the other Chaco Wash, which is usually dry but which frequently becomes a devastating torrent after hard rains. In both cases, underground crossings were made.

At the San Juan River crossing, an earthern dam was thrown up diverting the river to one side of the channel. The 34-in. pipe was then put into place on the dry side of the channel. The river was then diverted over the side of the channel under which the pipe line had been laid, and the crossing completed. The trench was blasted to an average depth of about 20 ft through tough blue shale. The pipe, after lowering in, was anchored firmly with clamps bolted 9 ft in the sand. The pipe was padded with sand and then weighted with boulders. Extra-thick pipe was used for the 800 ft crossing.

At the Chaco Wash, the arroyo bed was dry at the surface. Underneath, however, there was a great quantity of water. To keep the pipe line trench dry, it was necessary to drive well points into the ground, put pumps into operation, and to pump water out at the rate of thousands of gallons per minute. (These paragraphs are written prior to the actual laying of the line across Chaco Wash and it is not possible to give exact statistics on the pumping operation.)

Along the entire routes of the 34-in. and 20-in. lines, El Paso Natural Gas Company is maintaining crews of archeologists to recover artifacts of Indian civilizations that lie on or beneath the pipe line right-of-way. This

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policy was initiated in 1950 when construction of pipe lines in northern New Mexico and northern Arizona was first undertaken by the company. The federal Antiquities Act, which was enacted by Congress in 1908, sets forth procedures by which archeological sites can be excavated — either for the primary purpose of studying the sites themselves or for the removal of whatever is involved in other than construction on some project (a road, bridge, railway, or, as in this instance, a pipe line) can be undertaken. To meet the requirements of this act and, in addition, to recover for public goods artifacts not protected by the act the company has had crews of archeologists precede construction crews.

These archeologists first make surveys of the right-of-way. From such things as pieces of pottery and arrowheads, these men are frequently able to determine the existence of a dwelling site beneath the surface. Or, again, they frequently find the remnants of hogans, pithouses, and other structures on the surface.

Whenever an archeological site is discovered, proper steps are taken to excavate the material carefully and to make full scientific notes. The archeologists have been authorized to hire whatever labor is necessary to assist them to remove material properly. Once the material is out of the way, the pipe line crews move forward. Because most of the route of the 34-in. pipe line has been surveyed when previous pipe lines were built, archeologists do not anticipate any major discoveries on this route. The 20-in. line lies in territory not previously studied, however, and it is hoped that much new material will be uncovered. ★ ★ ★

The Author

Marshall Willis, advertising and publicity manager of El Paso Natural Gas Company, has been employed by the company for 10 years having served as accountant, measurement engineer, and editor of the company magazine, as well as in his present position. Prior to beginning work with El Paso Natural Gas Company he was, for one year, chief industrial engineer of a manufacturer of instruments and valves, and for three years market analyst for United States Rubber Company. He is a graduate of Texas Western College in El Paso and of Harvard University's Graduate School of Business Administration. He is a member of the Rotary Club of El Paso and the Harvard Club of New York.

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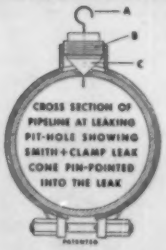

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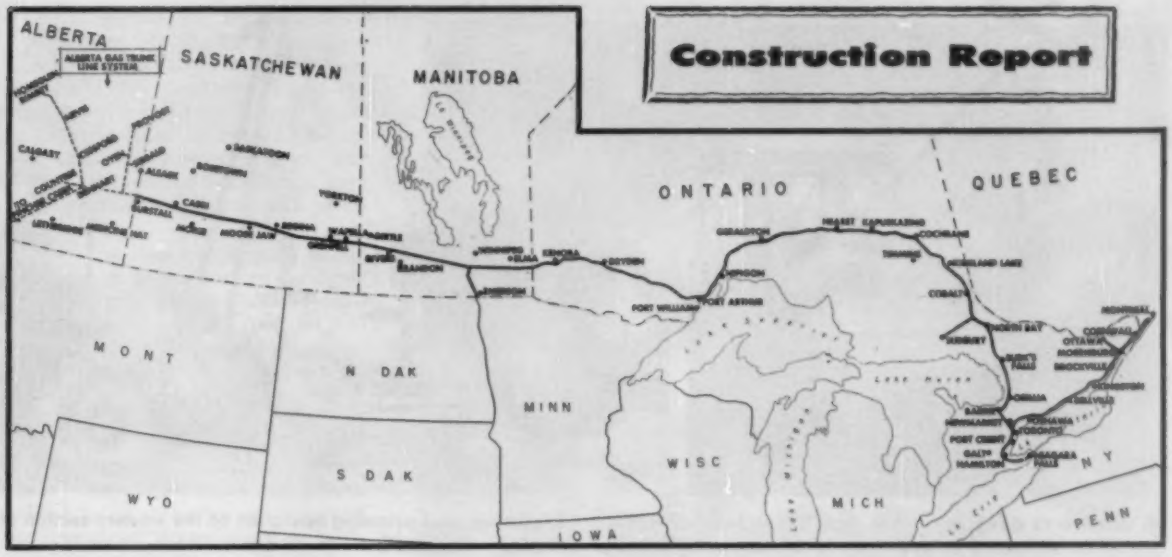
Construction Report



Western leg of 574-mile, 34-in. gas line well-underway—Laying of 30-in. east from Winnipeg starts in 1957

Trans-Canada Moves Into High Gear

D. W. Brown
Trans-Canada Pipe Lines, Ltd.

TRANS-Canada Pipe Lines, which will be the longest natural gas pipe line in the world when it begins delivering Alberta natural gas to the homes and industries in the Montreal area, 2250 miles distant, moved into high gear this summer when construction work started on the western leg — 574 miles of 34-in. pipe from Burstall, Saskatchewan, to Winnipeg, Manitoba.

Beset for almost two years by money and market problems, involved in Canadian politics this spring, Trans-Canada finally received government permission to start the line in June of this year. Within a matter of days active construction work was under way.

It was decided that seven spreads would build the line from Burstall to Winnipeg and the first two contractors on the job were Majestic Contractors, Ltd., of Edmonton, building spread one from Burstall 110 miles eastward, and Canadian Bechtel, Ltd., of Toronto, building spread two, also 110

Automatic submerged arc welder is shown here making the final weld in the double-jointing yard at Morse.

A ditch 6 ft deep and more than 3 ft wide is cut through the Saskatchewan prairies in a matter of minutes by this huge ditching machine, moving at better than a mile a day.

Cleaning and priming operation on the western section of the Trans-Canada line.

miles. Mannix, Ltd., of Calgary, and Dutton Williams Brothers, also of Calgary, received contracts for spreads three and four, respectively, but kick-off of these spreads was delayed by the steel strike in the United States and the resultant uncertainties of pipe delivery.

Canadian Bechtel was the first contractor to get under way. The company set up operations with almost $3,000,000 of brand new pipe line equipment, from massive sideboom tractors to four-wheel drive trucks and panel delivery wagons. Canadian Bechtel began operations north of Swift Current, Saskatchewan, and clearing of right-of-way and pipe stringing started in mid-June. First ditching was done early in July and by July 16 first pipe was buried in the ground, backfilled, and clean-up operations were completed.

Majestic Contractors moved into the Burstall area in mid-July and took off over the prairie farmland, anxious to have spread one catch up with spread two operations. By August 31, both spreads were making better than a mile a day.

In slightly less than two months between them both contractors had cleared and graded 186 miles of a total of 220 miles of right-of-way, pipe had been strung over 109 miles, 100 miles of ditching had been completed, 91 miles of bending, 88 miles of pipe welding, 86.2 miles of pipe had been cleaned, primed, coated, and wrapped, 83 miles had been lowered in the ditch, 73 miles of ditch had been backfilled, and 74.5 miles of right-of-way had been cleared up, terraced, tilled, and had fences restored.

For the most part the terrain has been greatly rolling farm land. Spread two had one heavy river crossing at Swift Current Creek where long, steep banks required extra attention, and this contractor also has had a fair share of swamp land, sloughs, and small bogs to cross. River clamps weighing 6000 lb were used in all swamp and slough country.

On spread one the only unusual feature on the route was the area where the operation ran 14 miles through the Great Sand Hills of southwestern Saskatchewan. This is an area of light, fine-grain sand, "a little Sahara" left from an early glacial age. The sand hills are covered by native grasses, scrub trees, and brush.

In the Great Sand Hills, spread one ditching operations were kept relatively close to the cleaning, coating, wrapping, and lowering in operations.

Firing line welders at work on the 34-in. line shown here in the rolling wheat land on spread one. As many as 38 welders at a time are working on this spread.

This latter operation was preceded a few hundred feet by a clamshell digger that cleared out ditch cave-ins where necessary. The contractor found the sand moist and well-packed at the time of construction in the area with the result that the heavy equipment had little trouble getting through and only a minimum of caving ditch with which to contend.

Trans-Canada plans to plant native grass and perhaps wheat on the right-of-way through the sand hills on completion of operations so that the prevailing winds will not blow away the sand cover and thus bare the pipe.

Ditch on both spreads has been made by conventional ditchers digging a ditch 72 in. deep and about 5 ft wide at the top. In the sand hills spread one ditchers encountered heavy root growth holding the scrub bushes and in spread two operations "nigger-heads" or boulders occasionally held up the ditchers briefly while the rock was winched from the trench.

Trans-Canada's 34-in. pipe is covered with anti-corrosive wrapping on both spreads. Bitumastic coating is used with fiberglass wrap embedded in the coating, both being covered with heavy duty kraft paper.

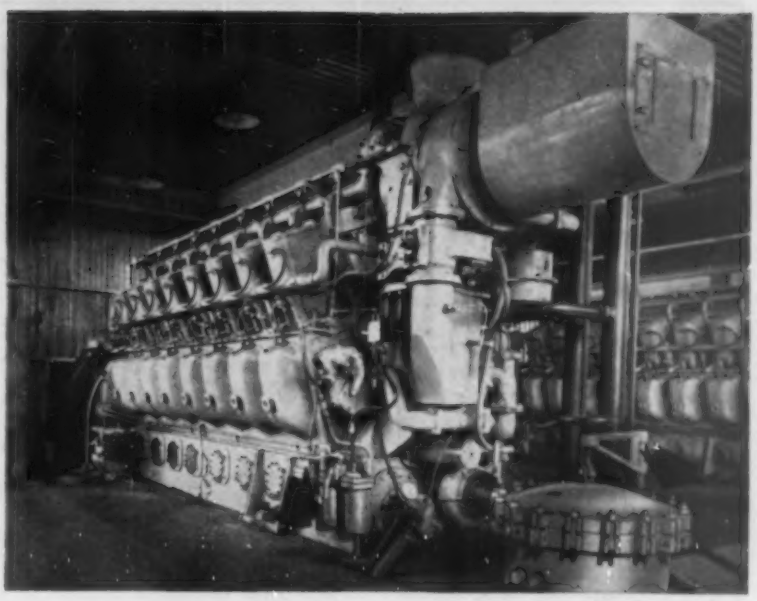
The 34-in. line pipe has ⅜-in. wall thickness and joints are in 40-ft lengths, each length weighing 5400 lb. Pipe on the western section is being manufactured by the National Tube division of U. S. Steel, and by the A. O. Smith Corporation.

Welds are checked by X-ray and gate valves are to be placed every 16 miles.

Canadian Bechtel introduced a double-jointing yard on its spread, using an automatic submerged unit, powered by two 600-amp units. The 40-ft lengths were trucked from the rail siding at Morse, Saskatchewan, to the yard, located in the same town. The joints were given stringer bead and hot pass welds manually and then rolled to the automatic welder for the final pass. The 80-ft joints were then inspected and X-rayed before being trucked to the right-of-way.

On completion of the 34-in. line from Burstall to Winnipeg, Trans-Canada plans to continue the line eastward, beginning early in 1957 with the laying of the 30-in. pipe east from Winnipeg.

Construction contracts have not yet been let for this operation of 1150 miles, and going through the area north of the Great Lakes is expected to present some interesting problems inasmuch as the area is largely rock and lake, with the rock areas heavily timbered. ★ ★ ★



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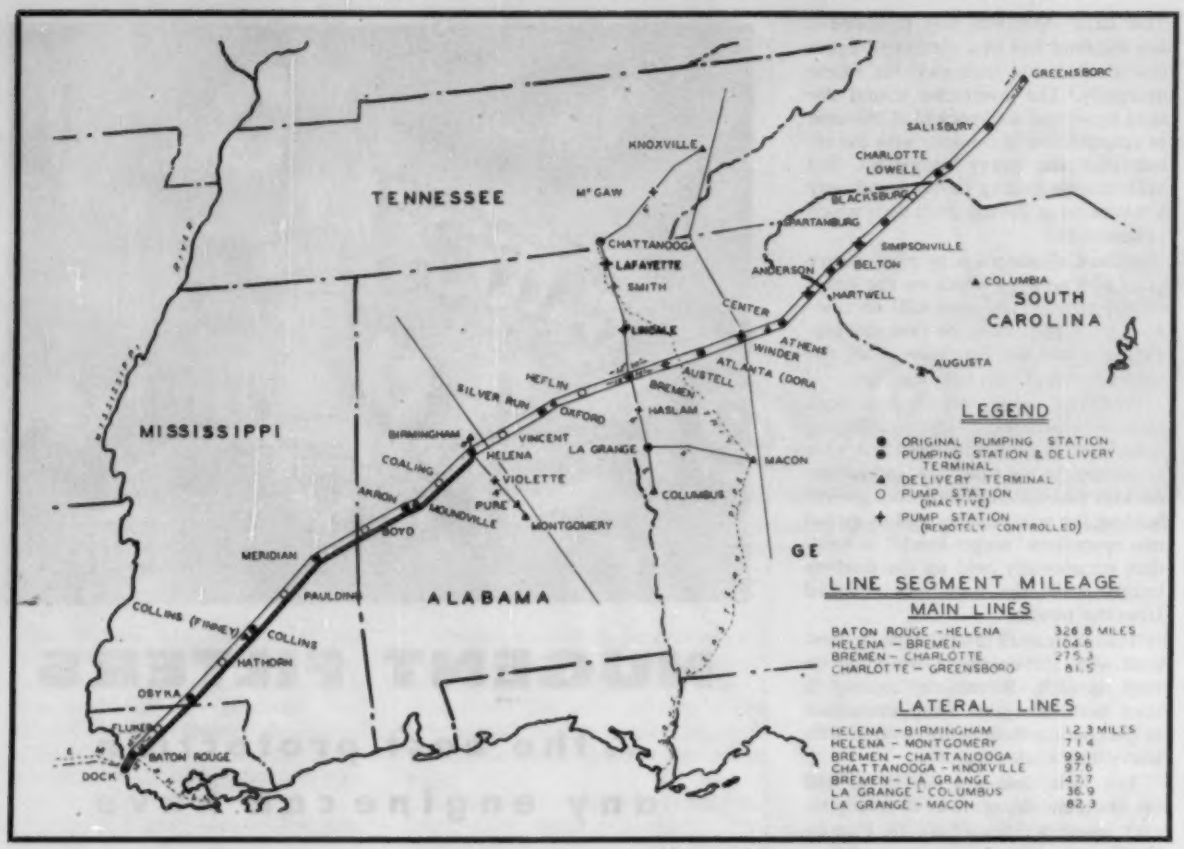

System map of Plantation Pipe Line Company. Present construction includes 326.8 miles of 18-in. from Baton Rouge, Louisiana, to Helena, Alabama; added pumping facilities and tankage at Baton Rouge; two new remotely controlled stations, at Lafayette and Lindale on lateral to Tennessee; three stations converted to remote operation, at Winder, Hartwell, and Simpsonville on main line into the Carolinas.

Construction Report

Plantation at Work On Long-Range Program

Looped lines, enlarged and new stations will up capacity by 60,000 bbl a day initially

PLANTATION Pipe Line Company of Atlanta, Georgia, has underway a looping and station enlargement program that will increase the capacity of its system by 60,000 bbl of products a day for the initial stage of a long-range program.

From Baton Rouge, Louisiana, to Helena, Alabama, 326.8 miles of 18-in. OD, ⅜-in. wall, seamless pipe is being laid parallel to existing 12-in. and 18-in. lines.

At Baton Rouge, 3600 hp is being added to pumping facilities, the equipment to be housed in the present station building. At this point, also, 165,000 bbl additional tankage is being erected.

Completion of the construction program is planned for about mid-December, 1956, depending upon receipt of pipe from the steel mills.

The pumping units being installed at Baton Rouge consist of two 1800-hp explosion-proof motors driving 2-stage, 10-in. by 12-in. by 14-in. centrifugal pumps. The pumps have a capacity of 8400 bbl per hour, and are equipped with mechanical seals. The motors are 4169-volt, 3-phase, 3600-rpm units.

Electrical power is purchased.

The new loop will be operated at a pressure of 975 psi.

Crossing of 11 rivers on the 327-mile route is lending some color to an otherwise more or less routine construction job. This is an average of a river crossing every 30 miles. The crossings are all 1000 ft or less in width and are single 18-in. lines. The pipe used for this purpose has a wall thickness of ½-in. as compared with ⅜-in. wall for the rest of the line. Concrete coating is being used over the regular coating and wrap, the latter consisting of enamel, glass fiber, and felt.

Line pipe is Grade B seamless, weighing 70.59 lb per foot, and comes in 40-ft joints. Welds are being checked by X-ray.

Oklahoma Pipe Line Constructors of Dallas, Texas, is laying the line.

When the new loop and pumping equipment are in operation Plantation's system will have a total mileage of 2377, a daily capacity of 304,000 bbl, and will be handling approximately 60 different products to 16 shippers at 18 delivery points.

There will be connected horsepower totaling 99,000, and tank farm storage capacity of 4,414,600 bbl distributed among Baton Rouge, Helena, and Bremen. Baton Rouge, where products are first received from ocean tankers, river barges, and other pipe lines, will have the largest storage capacity, 2,864,500 bbl. Helena and Bremen tank farms are needed for the operation of originating lateral lines. Tankage at Helena is 335,100 bbl, and at Bremen 1,215,000 bbl.

Prior to present construction, Plantation's system included parallel 18-in. and 12-in. lines from Baton Rouge to Bremen, Georgia, and dual 10-in. and 14-in. lines from Bremen to Greensboro, North Carolina. Laterals link other consuming areas to the main line. From Helena an 8-in. line runs north to Birmingham, Alabama, and a 4-in. south to Montgomery. From Bremen an 8-in. line extends to Chattanooga and Knoxville, Tennessee, to the north, and a 4-in. to Columbus and Macon, Georgia, to the south.

There are 17 manned and 5 remotely controlled pumping stations on the present system, and, upon completion of the work now in progress, 5 additional remotely controlled or satellite stations will have been added. Two of these will be new additions on the 8-in. lateral line into Tennessee and three will be reconverted stations that were in operation on the original 10-in. main line going into the Carolinas. All satellite stations will utilize leased wire for the transmission of the necessary intelligence for controlled operations.

* * *

how to CUT CORROSION LOSSES

a report by Koppers Company, Inc.

C. U. Pittman
Supervisor Technical Service

Ideally, effective corrosion control should start in the design stage of a new building or unit. The design engineer—by avoiding sharp edges, grooves, thin supporting members, etc.—can eliminate many of the common starting points for corrosion.

But in any case, the first step in preventing corrosion is *adequate preparation of the surface* before applying the protective coating. A really good—and economical—protective coating should *prevent* corrosion, not just cover corrosion products.

* * *

Most authorities agree that there are two chief objectives in good surface preparation: removing contaminating materials and producing a surface that will promote a good mechanical bond with the coating. The life and effectiveness of the coating system depends upon the degree to which you attain either of these objectives.

Actually, a tightly adherent surface of mill scale would make an ideal protective coating in itself—*if* temperatures remained constant. But since the scale and the virgin metal have different co-efficients of expansion, temperature changes and mechanical flexing cause flaking of the mill scale even under coatings. (Note: In over-the-ditch coating, it is not practical to remove all mill scale—buried pipe is not so subject to temperature change.) Another problem with mill scale is that electrochemical action between the mill scale and the metal accelerates corrosion and causes pitting.

Rust provides a certain amount of protection by slowing corrosion. But since it is non-adherent and porous, corrosion continues.

To perform an effective, long-life job, any coating must have a proper surface to which it can adhere. As revealed by photomicrographs, a slight roughness produces the best mechanical bond by increasing surface area and providing a tooth for the coating. Chemical bonding depends on the inherent molecular structure of the coating material. Some coatings must depend on a mechanical bond only. But coal tar coatings, having polar groups, will bond chemically as well as mechanically.

* * *

The important point on which most corrosion engineers agree—and which our applications research has proved—is that surface preparation is an integral part of the coating specification. By paying as careful attention to surface preparation methods as to selecting the right coatings, you will assure trouble-free, economical corrosion control.

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We will report to you soon on the various surface preparation methods. In the meantime, we'd like to hear about your corrosion problems. Write: Koppers Company, Inc., 1301 Koppers Building, Dept. 105K, Pittsburgh 19, Pa. District Offices: Boston, Chicago, Los Angeles, New York, Pittsburgh and Woodward, Ala. In Canada: Koppers Products, Ltd., Toronto, Ontario and Edmonton, Alberta.

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Construction Report

Texas Gas Adding 226 Miles, 30,970 HP, Microwave System

The 1956 expansion program in a six-state area will cost $27,000,000

TEXAS Gas Transmission Corporation this year is enlarging its pipe line system by approximately 226 miles, is adding 30,970 hp to its natural gas compressor facilities, and is installing a 700-mile microwave system as an aid to operations.

In all, the six-state 1956 expansion program of Texas Gas will cost approximately $27,000,000.

Pipe ranging in diameter from 6-in. to 30-in. is being laid in Louisiana, Arkansas, Mississippi, Kentucky, Indiana, and Illinois. Compressor facilities being installed include one new station in Louisiana and additional engines at nine existing stations at points between Louisiana and Indiana.

Texas Gas started its fifth pipe line across Arkansas and Mississippi with installation of the first 30-in. pipe in the company's system. Approximately 53 miles of 30-in. pipe was laid this summer in loops to two existing parallel 26-in. lines west of the Mississippi River in Arkansas, near Greenville, Mississippi, and near Clarksdale, Mississippi. Texas Gas already had two parallel 18-in. lines across these states in addition to the 26-in. lines.

The largest segment of the year's pipe line construction is scheduled for completion late this fall in the gas-producing area of South Louisiana. This will be 110 miles of 20-in. line extending from the southern terminus of Texas Gas' 26-in. pipe line system at North Tepetate, Louisiana, into the East Lake Palourde gas field.

A 9-mile extension was added to one of two existing 26-in. pipe lines in Ohio and Hancock counties, Kentucky; 21

Mississippi and Arkansas cotton fields were lined with pipe this summer as Texas Gas looped sections of its two parallel 26-in. pipe lines with 30-in. pipe.

Rivers both large and small were encountered along the route. Cast iron weights were used on the large streams' underwater lines, concrete weights on pipe in small streams such as the Sunflower River in Mississippi.

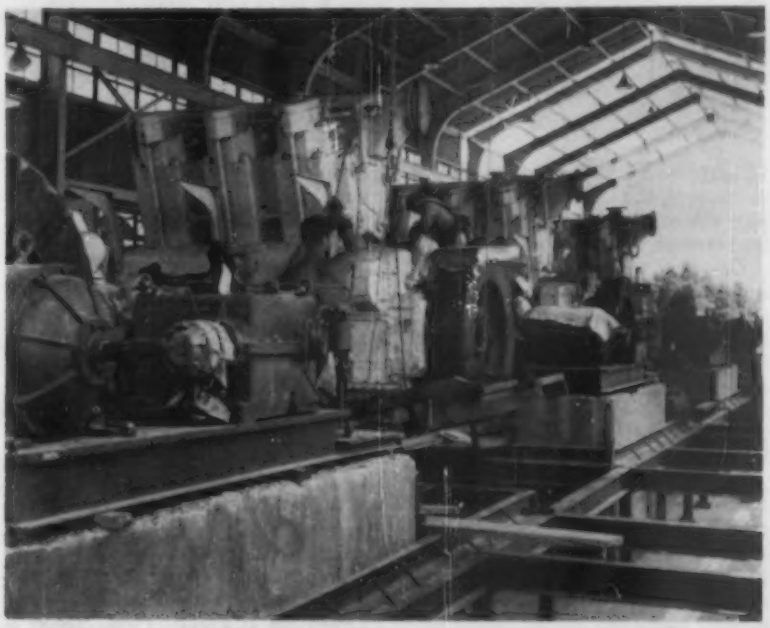
miles of 12-in. looping was done in Pike and Knox counties, Indiana; 11 miles of 16-in. and 13 miles of 10-in. gathering line looping is to be done this fall in Jefferson Davis and Acadia parishes, Louisiana, and approximately 9 miles of 8-in. and 6-in. line was laid at points in Louisiana, Kentucky, and Illinois.

Three rivers have been crossed or are scheduled for crossing yet this fall as a part of the pipe line construction program.

The largest of the river projects is a dual 20-in. crossing of the Mississippi River near Greenville, Mississippi. This job is being handled by Pentzien, Inc. Land-line work between the river and headers was done during the summer. The water portion will be done this fall from ramp barges.

The other river crossings, which have been completed, include two 16-in. lines under the Atchafalaya River, in Louisiana, as a part of the line to East Lake Palourde gas field, and a single 12-in. crossing of the White River in Indiana. Houston Contracting Company did the Atchafalaya crossing as a part of its general line construction contract, and Union Construction Company did the White River crossing, also as a part of its general construction contract. Lines were pulled across both the Atchafalaya and the White.

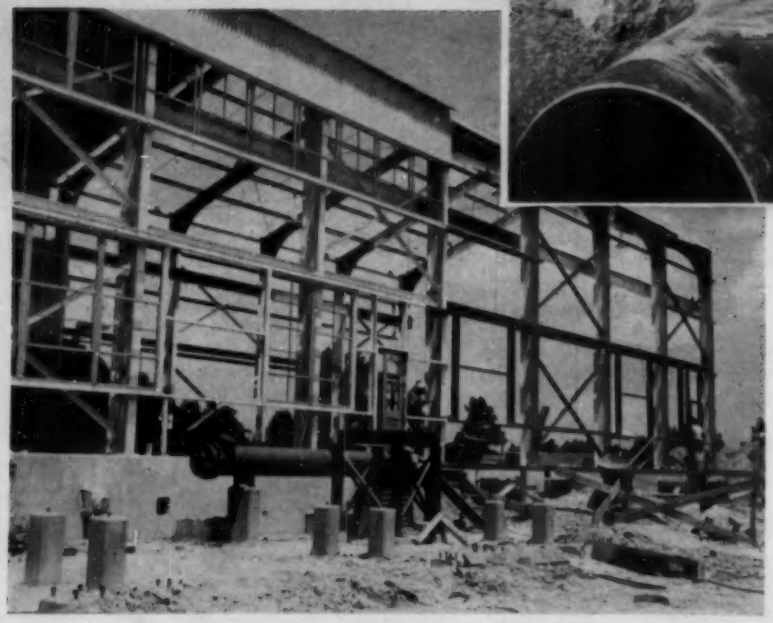
For the first time, Texas Gas is using pipe with a factory-applied concrete coating in a construction program. Approximately 90,000 ft of the 20-in. pipe going into the East Lake Palourde field line was given a 5/8-in. application of



Twenty compressor engines are being installed this year. In this picture are part of six 1500-hp engines going into a completely new station near Alexandria, Louisiana.

Header location for two 20-in. Mississippi River lines. In foreground is 30-in. pipe as it comes into the header. Twenty-inch lines leading to the river go off over the Mississippi levee.

Steel framework of the new compressor station near Alexandria, Louisiana, forms a pattern against the southern sky.



Somastic and a 2¾-in. application of Hevicote by H. C. Price Company. This pipe will be used in sections of marshland through which the line passes.

Cast-iron weights will be used on each of the river crossings.

Contractors who have built the year's land lines for Texas Gas are Williams Bros. Company, Houston Contracting Company, and Union Construction Company.

Compressor Additions

The 30,970 compressor hp being installed this year involves addition of 20 engines.* Six of them are going in near Alexandria, Louisiana, where a completely new station is being built. These six engines are 1500 hp each, for a total of 9000 hp.

Additions are being made as follows:

Columbia, Louisiana, three 1500-hp units.

Bastrop, Louisiana, two 2000-hp units.

Greenville, Mississippi, one 1320-hp unit.

Clarksdale, Mississippi, one 2000-hp unit.

Lake Cormorant, Mississippi, two 2000-hp units.

Covington, Tennessee, two 1500-hp units.

Slaughters, Kentucky, one 330-hp unit. Ingersoll-Rand.

Jeffersontown, Kentucky, one 1500-hp unit.

Dillsboro, Indiana, one 1320-hp unit.

Longview Equipment Company has the Alexandria, Columbia, Bastrop, and Greenville contracts; Ford, Bacon & Davis has those at Clarksdale, Lake Cormorant, Covington, Jeffersontown, and Dillsboro, and the installation at Slaughters is being handled by Texas Gas.

Microwave System

The microwave system will be installed by Radio Corporation of America, and will span a five-state area to link most compressor stations and key operational offices of the company.

The contract with RCA calls for erection of all necessary microwave station buildings and towers from Texas Gas headquarters at Owensboro to Texas Gas' Louisiana division offices at Lake Charles, Louisiana. Thirty-two stations will be established along the route, and initially the system will have 32 channels.

Four basic types of circuits are included in the initial 32 channels. These are:

1. A dispatching party line linking all points in the Texas Gas system from which natural gas is dispatched, compressor stations, and four terminal offices.

2. An operational party line for general operational traffic, connecting field offices, maintenance centers, and compressor stations.

3. An operational private line for maximum availability of communications between any two stations in the system.

4. A VHF radio control circuit that will enable persons at fixed locations to talk with employees in any of the VHF mobile radio units operated by the company. ★ ★ ★

* Manufacturers are Cooper-Bessemer, Clark Bros., and Ingersoll-Rand.

One phase of the transportation problem encountered by Dutton-Williams on the Westcoast Transmission line was eliminated by the use of house trailers; 77 of them were used for living purposes. In this rather remote area it would have been practically impossible for personnel to travel to and from work because of excessive distances and poor roads. Three Caterpillar electric sets provided power for the camp.

Photos Courtesy Caterpillar Tractor Co.

Construction Report

Canada's 1956 Construction Program Heavy to Gas Lines

Although the big jobs are gas, several important but shorter crude oil lines are being built

Leslie Orr Rowland

CANADIAN pipe line construction in 1956 swung heavily to natural gas, as the first major export line was advanced a long way toward its scheduled completion date — the fall of 1957. The largest program of natural gas pipe line construction in Saskatchewan for a single season also added substantially to the preponderant mileage of gas lines across the country.

Although the long-proposed Trans-Canada pipe line to eastern Canada failed to go ahead in its original form, and initially will terminate at Winnipeg, its sponsors will have managed to put 125 miles in the ground by the end of the construction season. The assurance of its completion to Winnipeg has prompted a start on city distribution systems in Brandon and Winnipeg, the two principal intermediate markets in the prairie provinces.

The project of Westcoast Transmission Company, Ltd., for 649 miles of 30-in. line from the Fort St. John gas field of northeastern British Columbia to Vancouver and across the international boundary to Washington, will be more than half completed by the close of the 1956 construction season, with a projected 400 miles to be in the ground.

Westcoast is employing four spreads, with total personnel of nearly 2000 men at peak of operations. Most of its route traverses country that is entirely new for pipe lines, although a portion of the southern sector parallels the route taken four years ago by the Trans Mountain oil pipe line. It will serve all the principal cities and towns of the interior region of British Columbia, from Dawson Creek down to Hope, including such major towns as Prince George, Kamloops, Nelson, Penticton, and Trail, all to be handled by a distribution system to be laid in 1957 by a subsidiary, Inland Natural Gas Company, Ltd., with total mileage of 875.

Two spreads on the 34-in. natural gas line being laid for Trans-Canada Pipe Lines, Ltd., will have completed this year almost one-fourth of the total

Conquering Angel Peak on Mannix Ltd. spread, Westcoast project required considerable effort and time. This particular grade of 40 per cent is 2000 ft in length. All equipment was winched up and then winched down.

of 575 miles. The entire mileage is scheduled for completion in the fall of 1957. This is the first pipe line in Canada to use 34-in. pipe. No serious obstacles of terrain have been encountered on this prairie job, except the normal ones of high water table and full sloughs at frequent intervals, which have kept daily footage down to little more than a mile on each spread.

The two sections, comprising a total of 215 miles, will be approximately 60 per cent completed this fall. This will utilize all pipe available at the time the steel strike began. Further pipe deliveries are not expected until the 1957 construction season.

One major water crossing was laid on the second section, under the Swift Current Creek, using 18 double-collar concrete river weights on 150-ft joints, which required eight pipelayers to lower in. Several major river crossings on the eastern sections will be left for next year and no others will need to be made on the first two sections.

The Saskatchewan Power Corporation's domestic gas grid network was built up substantially in 1956 by the construction of 125 miles of 12-in. main line from the Success field in the west-central part of the province to Moose Jaw in the east-central sector. Good late summer weather permitted the single spread on this job to make up to four miles a day and average nearly three.

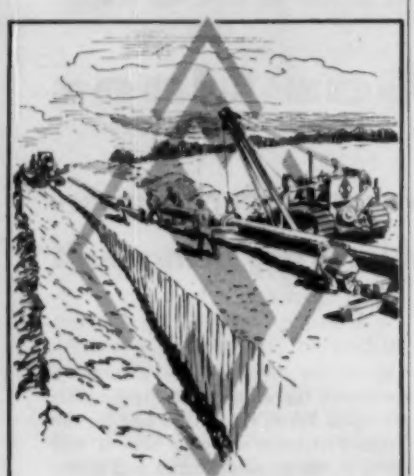
Besides this one large line, the SPC program included another 129 miles of smaller line. Extensions to Hoosier and Eston from the Brock field accounted for 42 miles of 4-in. to 10-in,. and the North Battleford trunk line called for 50 miles of 6-in., and the Humboldt trunk for 34 miles of 8-in.

City and town distribution systems in Moose Jaw, Swift Current, and other large towns in the area, as well as extensions to the existing systems in Saskatoon and Prince Albert, necessitated 8700 service connections and a total of about 1,400,000 ft of pipe.

In northwestern Alberta a double gas line, started in the winter, was completed the latter part of the summer, consisting of 34 miles of 10-in. from Alexander gas field to Lake Wabamun for Mid-Western Industrial Gas, Ltd., and 136 miles of 10-in. from Lake Wabamun to Hinton, Alberta, for North Canadian Oils, Ltd. Winter welding and pipe stringing were features of this job, with welding being done at minus 30 F for a short time. Extensive muskeg on a large proportion of the route compelled the use of rip-rap and heavy tracks for vehicles and machines, and a considerable backhoe ditching. Three major river crossings were installed through the ice during the winter.

Crude Oil Lines

In crude oil lines, the largest job was the construction of the 109 miles of 12-in. for Westspur Pipe Line Company from the Midale field in south-



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eastern Saskatchewan to the Cromer pumping station on the Interprovincial line in Manitoba. Despite bogs over half the route and a siege of extremely wet weather for three weeks, the entire job was done with one spread at the rate of nearly 2 miles a day, with top footage almost 20,000. The same spread moved down to Ontario in July to lay 38 miles of 12-in. line as a loop of Imperial Oil's Sarnia products line coming into North Toronto from Waterdown.

A looping program for Interprovincial Pipe Line Company in Manitoba involved construction of 67 miles of 24-in. and 2 miles of 26-in. line, which was put in the ground in six weeks with one spread. Generally dry weather helped to speed this job, although the water table in southern Manitoba was high and the sloughs were unusually full. The greatest water obstacle was a stretch of 4 miles of continuous swamp with water on the surface, all of which had to be ditched with backhoes traveling on rip-rap.

In Alberta, the 60-mile 8-in. line of Cremona Pipe Lines, Ltd., was laid in less than two months with one spread, despite a tough stretch of muskeg in the first 20 miles where right-of-way had to be rip-rapped extensively, as well as wet weather, which slowed operations almost throughout the job. This line joins the Sundre-Westward Ho fields with Calgary.

In the region south of Edmonton, farther north, the same spread laid the Rangeland Pipe Line Company, Ltd., line, consisting of 17 miles of 6-in. and 4 miles of 4-in., which connects the existing Gulf Pipe Line system southeast of Edmonton with the Texaco Pipe Line system southwest of Edmonton. The Texaco system was extended by construction of 22 miles of 12-in. line to tie in with the new line. Four rapidly developing fields are being served by these additions.

The latest job to start was the 58-mile, 8-in. extension to the South Saskatchewan Pipe Line Company system. In southwestern Saskatchewan, this addition links up the Dollard area fields with the existing line at Cantuar, a major oil producing area. This line was scheduled for completion late in September or early October.

Keeping pace with the fast development of the Pembina oil field, Pembina Pipe Line, Ltd., laid 170 miles of main line extensions and battery connections for its large gathering system, which picks up oil from Canada's largest oil field for shipment through its 79-mile, 16-in. main line to Edmonton. By winter, the Pembina system will consist of more than 300 miles and will serve 240 batteries connected to more than 1600 wells. ★ ★ ★

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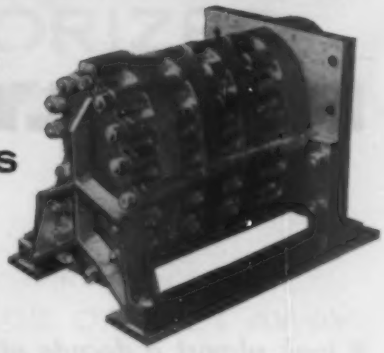

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Construction Report

FINALLY..... Canadian Gas Freed For Markets

It took almost a decade of effort... but now construction is underway that will provide needed outlets for 20-22 trillion cu ft of gas reserves

H. G. Cochrane

Power Corporation of Canada, Ltd., Montreal, Canada

AFTER almost a decade of effort to get western Canada's rapidly growing gas reserves to market, events the last few months have brought about a "breakthrough" at last. Just as development of Alberta oil and its export to Ontario and to the Pacific Coast have greatly stimulated Canada's growth, release of these huge reserves of natural gas to markets east, west, and south will have a further tremendous influence on the Canadian economy.

First solid accomplishment came last November, with Federal Power Commission approval of the Westcoast Transmission Company's tie-up with the Pacific Northwest Pipeline Corporation, to supply half of the 643,000 cu ft per day required for the rich and growing Pacific States market as far south as California. Westcoast also will supply Canadian markets in the interior of British Columbia and the City of Vancouver on the way.

Then, early in June, came final approval by the Canadian Parliament of a bill to authorize formation of a Canadian Crown Company to build a 675-mile section of the proposed Trans-Canada Pipe Line across northern Ontario. The same bill authorized a loan to Trans-Canada to enable them to build the western leg of its pipe line as far as Winnipeg this year, without attempting to risk financing the project before adequate markets were signed up.

Reserves Growing Faster Than Markets

Marketable reserves of Canadian gas have been building up much faster than markets. While Canada's reserves, estimated at 3 trillion cu ft in 1948, grew to 11½ trillion in 1953, and to between 20 and 22 trillion today, almost a sevenfold increase in eight years, actual gas production has been recording a little more than a threefold gain during the past decade. Wastage through flares has been building up to some 30 billion cu ft daily and many productive gas wells have been capped awaiting a market.

Compared with the share of the nation's energy supplied by natural gas in the United States, amounting to approximately one-fourth of the total, Canada lags far behind. Natural gas in Canada, supplying about 3 per cent of the nation's energy requirements a decade ago, is today filling some 6 per cent of the total. Another 7 per cent is contributed by electric power and the remainder is about equally divided between oil and coal.

Bigger Share of Energy From Gas

In another two decades, economists foresee Canada's total energy requirements doubled with natural gas supplying about 13 per cent of the total, or more than a fourfold increase.

H. Leigh Whitelaw, vice president of the Gas Appliance Manufacturer's Association, addressing the 49th annual meeting of the Canada Gas Association at Murray Bay, Quebec, predicted Alberta gas reserves would triple to 60 trillion cu ft by year 1980. He also forecast that within 10 years gas would be meeting more than 20 per cent of Canada's fuel requirements. He said Canadian gas would find American markets and help the continent as a whole to expand its fuel reserves.

These predicted gains for gas, however, do not necessarily imply a reduction in quantities of coal, oil, or electric power below current rates of usage. There will still be room left for coal consumption to increase by one-third and for oil consumption to double in Canada by that time.

'Oilsheds' Don't Follow Geography

Unlike the "Continental Divides" separating west-north-and east flowing watersheds in Canada, which are determined by topography, the country's "oilsheds" and "gas-sheds" are set by economics and by the availability of markets. With natural gas, political considerations enter into the divisions as well. Early gas pipe line projects visualized the export of gas from fields in southwestern Alberta to nearby Pacific northwestern states. But with the discovery of vast reserves in northern

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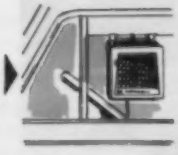

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Alberta and British Columbia it was realized that these were too far distant from Central Canadian markets, so northern Alberta gas fields were licensed to export westward and their production was added to that of British Columbia fields to serve Pacific States, whereas southern Alberta gas fields were earmarked either for domestic consumption or for markets in Central Canada and North Central States.

Westcoast Project Started Last Fall

The Westcoast Transmission project, with a six month head start, is already well under way with some 2000 men at work. Four contractors are working all along the 649-mile main line between the Peace River area and the International Boundary at Huntingdon east of Vancouver. Completion of construction is scheduled for late summer in 1957.

Meanwhile, work was begun in May on an $18,000,000 natural gas absorption plant near Fort St. John, B.C. This is a three-stage operation by which raw wet gas is scrubbed and cleaned, liquid hydrocarbons are removed, and elemental sulfur produced. The 250 to 300 tons of sulfur to be produced will more than fill the needs of the entire British Columbia pulp and paper industry. The plant will be added to as necessary, and is the forerunner of many new chemical industries for B.C.

What Gas Means to British Columbia

A 70-well gas drilling program in northern British Columbia costing $20,000,000 to $30,000,000 is in progress by Pacific Petroleums Ltd. So far about 5 trillion cu ft have been proved up in British Columbia's Peace River area, and the pace of exploration is being stepped up with construction under way. Extensive seismic search is in progress in the vast area stretching northward beyond Fort Nelson.

Sales contracts have been signed with most of the important communities by Inland Natural Gas Company, the distributor that will build the laterals from Westcoast's main-line to areas in the interior of British Columbia. Pipe line locations have been determined by aerial surveys, pipe has been ordered, and contracts are being awarded for laying the pipe.

British Columbia Electric Corporation, distributor for the Vancouver area, is building distribution lines in readiness for a temporary supply of imported gas from the Pacific Northwest Pipe Line this fall. Vancouver Island communities are going to be served through a submarine pipe line from Anacortes or Bellingham. British Columbia Electric Corporation will handle distribution on the Island.

Besides the investment in pipe lines of more than $150,000,000 during 1956 in British Columbia's oil and gas industry, Westcoast's contract with Pacific Northwest Pipeline will bring $600,000,000 into Canada during the next 20 years.

The project is already sparking new industrial ventures. One is a $1,800,000 sulfur producing plant near Pacific Petroleum's $18,000,000 gas absorption plant now building at Fort St. John. Start on the absorption plant was quickly followed by a contract between Pacific Petroleums and Jefferson Lake Sulfur Company of New Orleans for the sulfur venture.

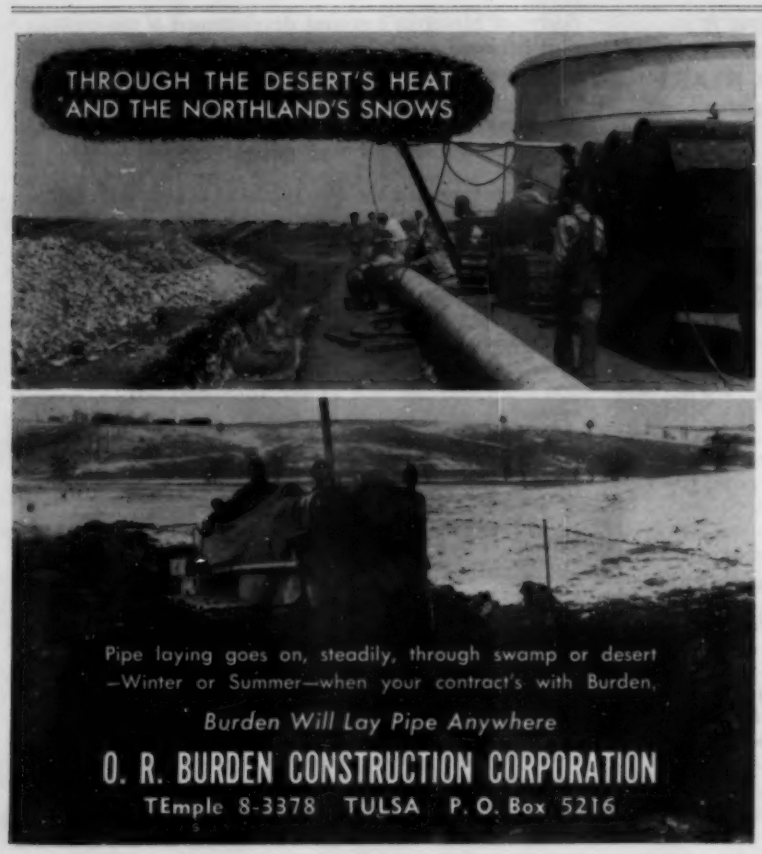
Parliamentary Logjam Broken

After several six-month extensions for the date when Trans-Canada had to prove its ability to finance its 2300-mile project for bringing Alberta gas to eastern Canadian cities, Parliament, after a long and bitter debate, approved legislation to enable a start this year. This was in the form of an act setting up a crown company jointly with the Ontario government, which would build the $118,000,000, 675-mile pipe line section across the sparsely settled area north of the Great Lakes between the Manitoba Border and Kapuskasing, Ontario. The act also authorized a 10-month loan of $80,000,000 to Trans-Canada to enable the company to complete its 574-mile western section from the Alberta-Saskatchewan border to Winnipeg by December 1, 1956.

Under terms of the government loan, should the line not be completed to Winnipeg by December 1, the Canadian government may take over Trans-Canada's entire assets at 90 per cent of cost. There is little likelihood of this happening, however, as interference with the company's progress due to "Force Majeure," such as floods, riots, or strikes, would automatically extend the time for completion under the terms of the loan.

Gathering System

Earlier plans contemplated a 547-mile gathering system in Alberta, 219 miles of which were to be built in 1956. Due to Trans-Canada's current schedule to build only as far as Winnipeg this year, however, it is reported the Alberta Gas Trunk Line Company plans are now modified to building only 30 miles from the Bindloss field. This field will supply the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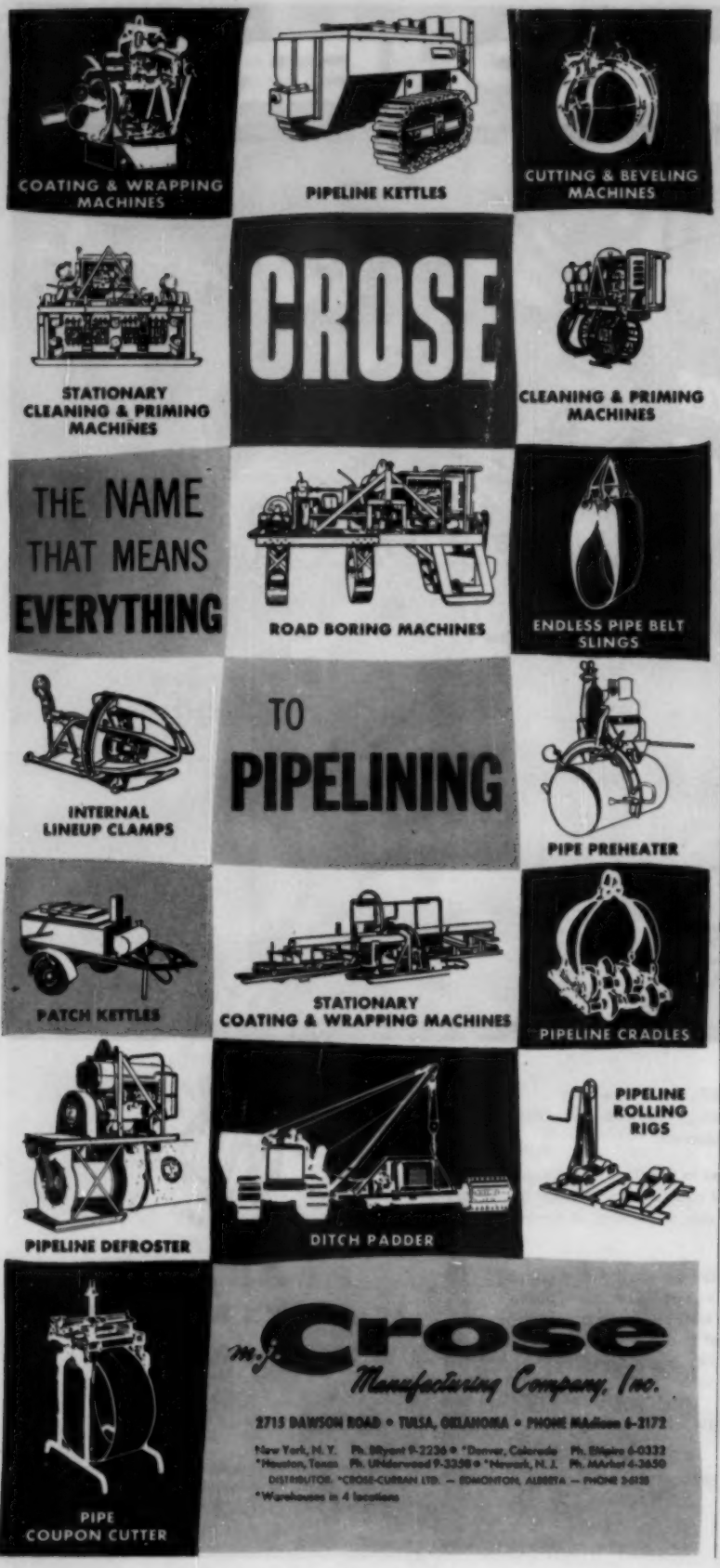
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smaller volume of gas needed the first year. The gas is sweet and dry, with field pressure sufficient to push it right through to Winnipeg.

Operation of B. A. Oil's new sulfur plant 13 miles southeast of Pincher Creek is scheduled for about October 1. Output will be 225 long tons of sulfur and 2200 bbl of concentrate daily. Capacity will be doubled when the pipe line reaches the Toronto market, and ultimate capacity will be 780 tons of sulfur, 1230 bbl of propane, 1300 bbl of butane, 1020 bbl of natural gasoline, and 7810 bbl of concentrate per day.

During the first year operation prior to completion of the pipe line the residue gas from the Pincher Creek field will be recycled. Later, residue dry gas will be sold to Trans-Canada at a rate of 1,000,000 cu ft a day the first year and 1,700,000 cu ft a day in subsequent years.

The Author

H. G. Cochrane is a member of the Engineering Institute of Canada. After spending his early years on irrigation development in Alberta and Saskatchewan, he went east to build a number of large hydro-electric power plants in Quebec and Manitoba. He became interested in oil development in the late thirties while making preliminary studies and estimates of oil pipe lines to Lakehead and the Pacific Coast.

During World War II he conducted economic studies on scarce materials and services for the Canadian Government. He is presently with Power Corporation of Canada, Ltd., Montreal.

Market in Central Provinces Only Solution

This 34-in. "Western Leg" built as far as Winnipeg only could never be expected to pay for itself out of revenue from gas sales to Canadian prairie cities and towns alone. Gas for this area could be supplied adequately through a much smaller line, possibly 18 to 20-in. in diameter. But a market in Central Canada is now ultimately assured through passage of the pipe line bill authorizing the crown company to build the 675-mile northern Ontario gap next year. Thirty-inch pipe for the entire 1263 miles from Winnipeg to Toronto already has been ordered from British and Canadian mills. If Trans-Canada cannot carry out its financing next year there is little doubt that the government would complete the project from Kapuskasing, the east end of the northern Ontario gap, into Toronto.

Canada's declared policy is that the central provinces must be supplied before an export permit is given for the

200,000,000 cu ft daily contracted for by Tennessee Gas Transmission Company for delivery at the U. S. boundary at Emerson, Manitoba. The immediate Canadian need was the market in southern Ontario, with a contingent or future need in northern Ontario north of the Great Lakes. The pipe line had to be located that way. Without government interference at Washington, Edmonton, and Ottawa the gas could have been piped first to nearby markets where there was a ready demand. Instead, capital was needed to move the gas to remote and slow growing markets. Someone had to be ready to carry the project until it would begin to show a profit.

The 200,000,000 cu ft daily to Tennessee Gas Transmission, even if given an FPC blessing, is only half as much gas as the "Western Leg" can carry and thus not a big enough throughput alone to show a profit. Trans-Canada officials are skeptical, anyway, as to an early favorable outcome of the FPC hearings. Issue at stake is approval for the import of Canadian gas to the North Central States, and all signs point to a long legal battle. Although still striving for an entrance to this big midwestern states market, which would at once simplify all the financing problems, the company realizes its only chance for survival is to develop the Canadian market.

It has therefore set itself a target — to sign up enough long term sales contracts in Canada by the fall of 1956 to justify the $250,000,000 of pipe line financing needed to complete the line into Toronto and Montreal, exclusive of the northern Ontario government-built segment, which they can lease for the first 10 years.

To make the project attractive to underwriters and investors, enough revenue would have to be assured by the third year of operation to pay all fixed charges and operating expenses. For a break-even point the third year, delivery of a minimum of some 150 billion cu ft yearly likely would be needed.

That was actually the target for Canadian sales for the fifth year set some three years ago, but latest market surveys show a much more optimistic outlook for load. Trans-Canada officials have their sights set for close to that amount for the second or third years of operation.

Breakdown of Canadian Market

There are six major market areas that give hopes of making early financing possible through the signing up of firm sales contracts. They are: (1) The area served by Winnipeg and Central Gas Company; (2) the area north of the Great Lakes, served by Northern

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Natural Gas Company; (3) the metropolitan area of Toronto served by Consumers Gas Company; (4) southwestern Ontario, served by Union Gas Company, Dominion Natural Gas at Brantford, Provincial Gas at Fort Erie; (5) the Ottawa-Hull area, served by Interprovincial Gas Company and (6) the Montreal area, to be served by a subsidiary of Trans-Canada, which has an option to purchase the gas distribution system in the Montreal area owned by Hydro-Quebec.

Winnipeg and Central Gas Company will get Alberta gas at a price 25 per cent lower than the manufactured gas it uses now. Though sales today only amount to 1,500,000 cu ft a day, the gas company expects a buildup to 28,000,000 cu ft daily the fifth year. This is based on expectation of large industrial contracts such as the Canada Cement plant at Fort Whyte.

Northern Natural Gas has signed a sales contract for 100,000,000 cu ft daily for the fifth year. This includes some processing gas sales to International Nickel Company, Inc., but excludes a potential 40,000,000 cu ft per day market for nickel smelting.

After a two-season buildup with imported gas from Gulf states, Consumers Gas has a current market of 15,000,000 cu ft daily. The enlarged market area now takes in most of metropolitan Toronto, out to Oshawa and Whitby to the east, to Brampton on the north and Port Credit to the west, and takes in a population of almost 1,500,000 people. Estimated fifth year consumption made three years ago based on the original franchise area was 25 billion cu ft yearly. Today it would be very much higher.

Union Natural Gas, which serves the southwestern areas of Ontario, including Hamilton, has recently signed up the most extensive long term gas contract ever signed in Canada. Beginning with 12½ billion cu ft the first year, it increases to a maximum of 64 billion cu ft by the 13th year and continues at the quantity for the balance of the 20-year contract. Under a previous contract with Trans-Canada the volume would have leveled off at 15½ billion cu ft in the sixth year. This will provide Trans-Canada with a gross revenue of some $300,000,000 during the life of the contract.

Union Gas Contract Big Boost

The Union Gas agreement is particularly helpful to Trans-Canada, in that it provides for delivery of approximately two-thirds of the gas required each year during the summer months when customer requirements are at a seasonally low level. Union can take much heavier summer deliveries because of underground storage fields in Lambton County, which enables it to build up reserves in the summer months for winter delivery, and to back off the Trans-Canada line entirely in periods of severe winter conditions.

Recent FPC approval for export of up to 15,500,000 cu ft of U.S. gas yearly to Union now will enable a rapid expansion of the market in southwestern Ontario, and will make available a much wider market for Alberta gas the first year the pipe line reaches Ontario. Imported gas must be replaced by Alberta gas within one year of the time Trans-Canada's line is completed. This is going to make Trans-Canada's task of financing a lot easier.

Beyond these are the markets in Ottawa-Hull, the huge Montreal area, and other eastern Ontario cities such as Belleville, Peterboro, Brockville, Kingston, and Cornwall, where efforts are under way to sign up further firm contracts. These are the reasons why Trans-Canada officials feel there is a good chance of clearing the way for financing by year's end on the basis of Canadian sales alone.

Products Pipe Line To Be Tied In

A third major pipe line system, from Alberta to eastern Canada, this time a products pipe line, is awaiting approval from the Board of Transport Commissioners and the Alberta Conservation Board. This project, to be integrated with the Trans-Canada Pipe Line, would move large quantities of liquid hydrocarbons from the "wet gas" fields of Alberta, which are removed from the gas before it enters the pipe line. Being a common carrier, this products pipe line also would move refined gasoline from Edmonton and Moose Jaw refineries to Winnipeg. This gasoline would be its "bread and butter" load.

Besides the natural gasoline recoverable from wet gas fields, such as Pincher Creek, to be delivered to refineries along the route, propane and butane would be carried in liquid state under pressure and sold as heating fuels to distributors and industry along the route. Butane would sell partly as a raw material for refinery or petrochemical operations.

Exclusive of its own gathering system in Alberta, the 8-in. and 6-in. pipe line itself will be 800 miles long from Alberta to Lakehead, and will be provided with underground and above-ground storage facilities along the route. Terminating at the Lakehead cities of Fort William-Port Arthur, it calls for the addition of eight or more specially built pressurized Great Lakes tankers to move the fuel from Lakehead to eastern markets along the Canadian side of the Seaway and even

beyond. Considerable storage also will be required at Lakehead for the five winter months of closed navigation. Orders already are being placed for pipe from Canadian mills, and construction will begin in 1957.

Hydrocarbons Pipe Line, Ltd., has been incorporated as a subsidiary of Canadian Hydrocarbons, Ltd., and Superior Propane, Ltd., the sponsors of the project. The former propose to operate the line as far as Winnipeg. They expect a throughput to Winnipeg of some 133,000,000 gal of products the first year and at least double that quantity the 10th year. Superior Propane, which now sells about a third of all residual propane marketed in Ontario, proposes to extend the pipe line to the Lakehead at Fort William for a throughput averaging about half the volume to be carried to Winnipeg.

The estimated cost of the combined project, including the eight tankers for the Great Lakes, is estimated at from $55,000,000 to $60,000,000.

Full development of the Trans-Canada project will make available some 100,000,000 gal of propane yearly. This production, added to the current Canadian production of about 40,000,000 gal poses a stiff marketing problem; however, Canadian sales of propane have been increasing at the rate of 33 per cent annually, and considerable quantities now are imported from United States.

The project will make large quantities of raw materials available for chemical operations in the Winnipeg and Lakehead areas, and the pipe line may some day be extended to Sarnia, Ontario.

Must Fuel Markets Be Divided?

Canadian "conservationists," watching the rivalry between petroleum and coal interests, foresee the need in Canada for a "Fuel Board" to define the economic boundaries for gas and coal, so each of the fuels, of which Canada has abundant resources, may have its proper share of the fuel markets.

Most of the Province of Ontario imports it coal from the North Central States, but coal from the Maritime Provinces has an economic reach into most of the Province of Quebec. It has been suggested that the Ottawa River might be set as the boundary between markets to be served by gas and by Maritime coal.

Only a fuel authority set up by Canada's federal government could set these limits. Whether Trans-Canada Pipe Line continues as a private enterprise or falls into the lap of government through inability to finance the project, the division of Canada into fuel market areas would be fraught with many difficulties. ★ ★ ★

Pipe Line Projects

Tennessee Gas Announces $166,000,000 Program

Tennessee Gas Transmission Company has filed an application with the Federal Power Commission to construct a major enlargement of its system. The $166,000,000 program would add 456,000,000 cu ft to the average-day delivery capacity of the system.

The proposed new facilities include 1085 miles of pipe line, six new compressor stations, enlargements of seven existing stations, and a new triple-pipe line underwater crossing of the Mississippi River.

A main feature of the application is a 557-mile, 30-in. line that would begin in the Mississippi River delta area south of New Orleans. It would connect the east end of the company's newly-completed "Muskrat" gas gathering line with the main system at Portland, Tennessee.

Another smaller but significant part of the project is 120 miles of 12, 20, and 26-in. line from the compressor station at Kinder, Louisiana, south to the shoreline and into the Gulf of Mexico to offshore wells where some two trillion cubic feet of gas reserves newly contracted for by the company are located. Some 68 miles of this pipe line would be under Gulf waters.

Also proposed are 332 miles of pipe line parallel to the existing system, including 276 miles of 30-in. and 26-in. line in Kentucky, 39 miles of 26-in. in West Virginia, and 22 miles of 26-in. and 24-in. in Pennsylvania.

A 76-mile, 24-in. line would start at the company compressor station at Coudersport, Pennsylvania, which is adjacent to its Hebron and Harrison storage fields, extend northwest through the Colden storage field to a compressor station near Buffalo, New York.

The compressor station phase of the overall project includes six new stations with a total of 53,700 hp, to be located in Mississippi, Tennessee, New York, and Pennsylvania, and 63,540 hp in enlargement of seven existing stations in Tennessee, Kentucky, Ohio, and Pennsylvania.

Colorado Interstate Amends Construction Proposal

Colorado Interstate Gas Company has filed with the Federal Power Commission an amendment to its large Beatrice Project. Included in the amendment, on which FPC hearings open October 2, is the redesign of the transmission system expansion originally proposed in March, and the retirement from service of some facilities along the company's original transmission line from the Texas Panhandle to Denver.

New transmission facilities proposed by Colorado Interstate in its amended application include:

(1). A 215-mile line ranging in diameter from 26 to 34 in., from Texas Panhandle area to the Kit Carson Station. This line will parallel the present transmission line between those two locations and is sized to handle the gas presently being transported in the company's old line between the Texas Panhandle and Denver, as well as the additional gas to be transported for the Rocky Mountain and Midwest areas.

(2). A 100-mile, 24-in. line between the company's Springfield compressor station and Pueblo.

(3). A 345-mile, 30-in. line running directly from Kit Carson to Beatrice, Nebraska.

(4). A 50-mile, 22-in. extension of the company's line at Hooker, Oklahoma, to transport recently acquired reserves from the Mocane and Laverne fields in Beaver and Harper counties, Oklahoma, into Colorado Interstate's transmission system. Flow in the company's present Hooker line will be reversed to move these new supplies westward.

(5). A 24-mile, 24-in. new line from the Greenwood area to the Panhandle-Kit Carson loop system, which will parallel an existing line.

(6). A total of 60,980 compressor hp. New compressor station facilities are planned at Table Rock, Walcott, and Laramie, Wyoming, along the Rock Springs-Denver line, and at Morland, Kansas, along the Kit Carson-Beatrice link. Horsepower capacity will also be boosted at seven existing compressor stations under the new proposal.

The total cost of the transmission facilities proposed under the amendment is estimated at approximately $87,000,000. This is part of a two-year expansion program of Colorado Interstate for 1956 and 1957 that will cost approximately $120,000,000. Included in that two-year program are completion of the company's transmission line from Rock Springs, Wyoming, to Denver, which is now under way and additions to producing properties and gathering line.

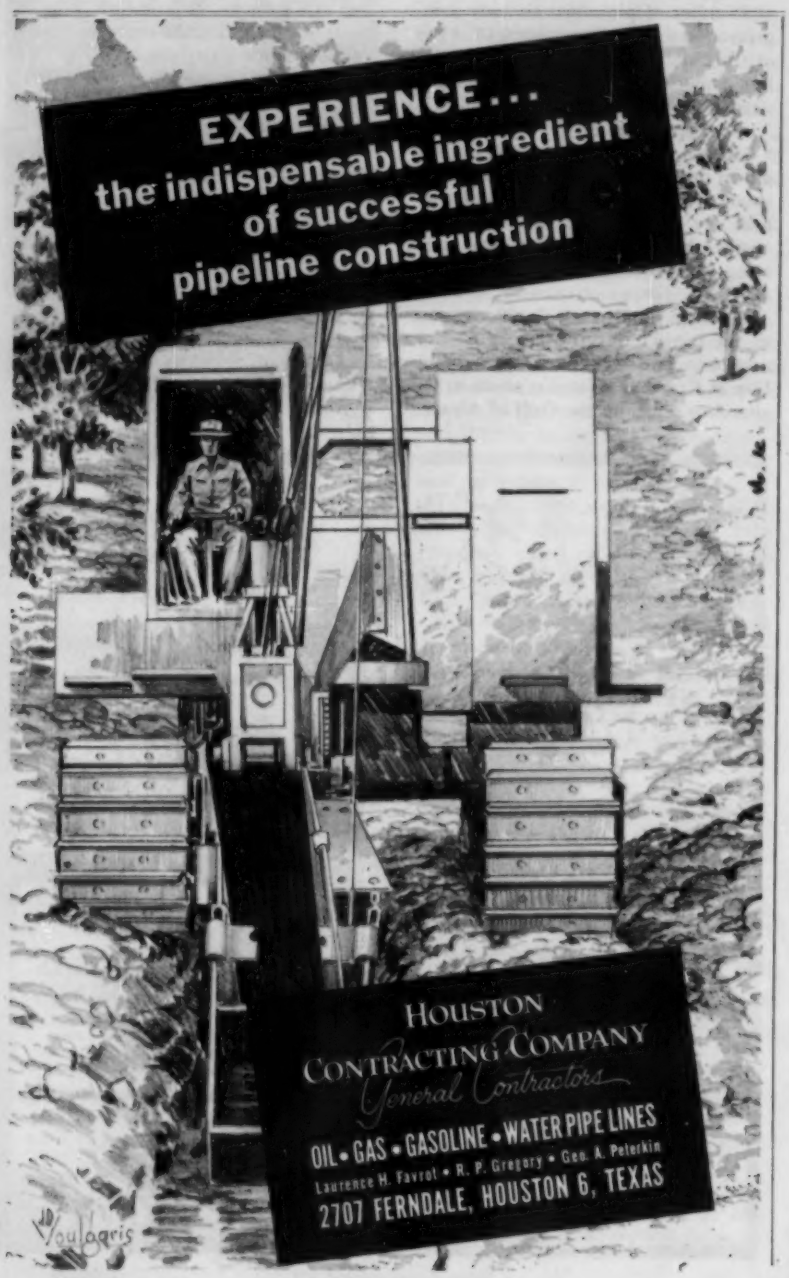
Facilities to be retired from service include seven compressor stations with a total of 27,115 installed hp, at Dalhart, Texas; Clayton, New Mexico; Cimarron, New Mexico; Canyon, southeast of Trinidad, Colorado; Apishapa, near Delhi, Colorado; Devine, at Pueblo; and McClintock, north of Colorado Springs.

Also to be retired from service are approximately 87 miles of 22-in. transmission line between Clayton, New Mexico, and the City of Trinidad, Colorado, lateral.

Fulton Awarded Contract For California Gas Line

R. H. Fulton and Company of Lubbock, Texas, has been awarded the contract to construct a 241-mile, 30-in. natural gas pipe line from Newhall to the Colorado River near Needles, California, the major portion of a 33,500,000 project jointly undertaken by Southern California Gas Company and Southern Counties Gas Company. It will bring an additional 278,200,000 cu ft of gas a day into Southern California.

A 49-mile pipe line from Newhall to Alhambra, which will connect with the



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major line, is now under construction, and is expected to be completed by December 1.

Vice President Grove Lawrence of Southern California Gas Company said that crews from R. H. Fulton and Company will probably begin initial right-of-way work, grading, and trenching in October, with actual pipe line work getting under way in January. The line is to be completed and in operation about June 30, he said.

Pipe for the project is being manufactured by the Consolidated Western Steel Division of U. S. Steel Corporation at its Provo, Utah, plant.

New Stations Will Boost American Louisiana Capacity

American Louisiana Pipe Line Company, of Detroit, Michigan, has been granted temporary authority by the Federal Power Commission to construct and operate natural gas facilities estimated to cost $8,658,000.

The facilities are part of a $16,078,000 construction program designed to expand American Louisiana's daily delivery capacity from 300,000,000 to 400,000,000 cu ft. The facilities for which the temporary authorization was made are two new compressor stations of 12,000 hp each and the addition of 2000 hp at each of two presently certificated stations. These facilities will increase American Louisiana's daily delivery capacity by 60,000,000 cu ft.

American Louisiana is authorized to sell gas to Michigan Consolidated Gas Company and Michigan Wisconsin Pipe Line Company, both of Detroit. All three companies are subsidiaries of the American Natural Gas Company.

South Dakota Project Northern Natural Approved

The Federal Power Commission has issued a certificate to Northern Natural Gas Company, of Omaha, Nebraska, authorizing a total of approximately 354 miles of pipe line and 18,640 hp in compressor capacity to increase the sales capacity of the company's system in the Midwest by approximately 65,092,000 cu ft per day.

The project includes a 163-mile pipe line extension of Northern's system from the Sioux Falls, South Dakota, area, to Aberdeen, South Dakota, together with about 160 miles of branch lines to serve 20 new wholesale customers in South Dakota.

The authorized facilities are part of a large expansion program proposed by Northern, which also includes an extension of the company's system to the Duluth-Superior area. The latter part of the project is in competition with

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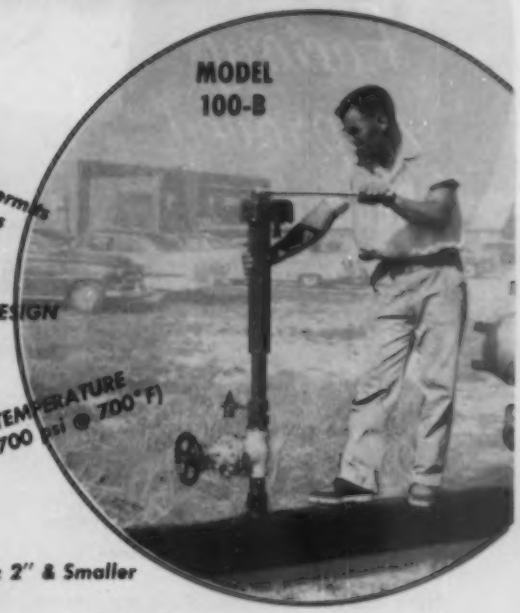

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the proposed system of Midwestern Gas Transmission Company, of Houston, Texas, whose application is pending before the FPC. Further hearings on this part of Northern's proposed project will be set by further FPC order.

Colorado Interstate Facilities Authorized

The Federal Power Commission has granted Colorado Interstate Gas Company, of Colorado Springs, Colorado, temporary authority to construct and operate natural gas facilities estimated to cost $3,041,877.

The facilities are a portion of the $76,619,958 facilities for which Colorado Interstate has requested authorization in order to increase its deliveries to Natural Gas Pipeline Company of America by approximately 350,000,000 cu ft per day.

The facilities for which the temporary authorization was granted consist of 23.5 miles of 16-in. loop line between the Morton County, Kansas, station and the Fourway-Kit Carson mainline; 8000 compressor hp, dehydration plant additions, and check meter station addition at the Morton County station.

Colorado Interstate stated in its application for the temporary authorization that the facilities requested would be required, regardless of the outcome of the main applications, in order to market gas that must be taken under minimum take-or-pay-for purchases in the Greenwood field area.

Texas Additions Approved For El Paso Natural

The Federal Power Commission has granted El Paso Natural Gas Company, El Paso, Texas, temporary authority to construct and operate natural gas facilities in Texas.

These proposed facilities, estimated to cost $1,004,000, including 28.1 miles of 10¾-in. pipe line in Nolan and Coke counties; construction of the Jameson compressor station, with an installed horsepower of 1320; construction of a purchase meter station, and appurtenant facilities. It is proposed to build other field processing and gathering facilities in connection with this project.

El Paso stated in its application that the facilities would be required for the acquisition of up to 20,230,000 cu ft a day of residue natural gas from West Lake Natural Gasoline Company, a wholly-owned subsidiary of El Paso Natural Gas Company. The gas will be transported into El Paso's general transmission facilities in the Permian Basin for delivery to its existing customers.

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Giant ditching machines prepare a trench into which Texas Eastern's recently completed 30-in. line will be placed and buried. **Welders** (right) join two sections of weight-coated pipe to be used at a river crossing site.

P 620.

Construction Report

Texas Eastern System Made More Flexible

Added compressor horsepower, laying of laterals and connecting lines also increase capacity by 220,000,000 cu ft a day

CONSTRUCTION of a new 379-mile 30-in. gas pipe line between Beaumont, Texas, and Kosciusko, Mississippi, has recently been completed by Texas Eastern Transmission Corporation. The new line is a part of facilities constructed to increase the flexibility of the company's operations in its supply areas.

Overall cost of the new facilities was approximately $65,000,000. Included in the program were eight new compressor stations, additions to certain existing stations, the new Beaumont-Kosciusko line and approximately 100 miles of additional lateral and connecting smaller diameter lines. The new facilities have increased the capacity of Texas Eastern's 30-in. line by approximately 220,000,000 cu ft a day.

The new 30-in. line extends from a point near Beaumont through southern Louisiana and central Mississippi and connects with an existing 30-in. line at Kosciusko. It crosses four major rivers and one bayou — the Neches, Sabine, Atchafalaya, and Mississippi rivers, and Bayou Courtableau. Two lines were laid at each crossing for added protection.

A total of 122,420 hp has been added by Texas Eastern, 91,400 hp in the new compressor stations and 31,020 hp in existing stations. Two new reciprocating stations were installed in Texas, at Booth and Vidor. The Booth station has two 1100-hp reciprocating engines; Vidor has five 1000-hp reciprocating units. An 8800-hp reciprocating station was built near Holbrook, Pennsylvania. Three new electric motor driven centrifugal stations, each with one 15,000-hp unit, were constructed at Egypt, Mississippi, Mt. Pleasant, Tennessee, and Tompkinsville, Kentucky. Two gas turbine driven centrifugal stations, each with two 7600-hp units, were constructed at Athens, Ohio, and Owingsville, Kentucky.

Additions to existing stations include 5000 hp in reciprocating units at Kosciusko, Mississippi; 3520 hp in reciprocating units at Danville, Kentucky; 7500 hp in electric motor driven centrifugal units at three stations — Barton, Alabama, Gladeville, Tennessee, and Wheelersburg, Ohio.

Greater flexibility for Texas Eastern's operations in the Philadelphia-New Jersey area were provided as a result of FPC authorization of a joint application of Texas Eastern and Texas Eastern Penn-Jersey to shift 10,000 hp installed or authorized on the Texas Eastern system to the Penn-Jersey system.

The shift allowed construction of two new 5000-hp stations on the Penn-Jersey system, at Grantville and Peru-

Concrete-coated river pipe rests on the bank awaiting completion of one of Texas Eastern Transmission Corporation's river crossings in South Louisiana.

lack, Pennsylvania. Both are gas turbine centrifugal stations. Other facilities authorized include an additional 3300 hp in reciprocating units at Texas Eastern's Linden, New Jersey, station and construction of 11 miles of loops in the Philadelphia area.

Wilcox Trend Gathering System, Inc., a Texas Eastern subsidiary, increased its daily capacity to approximately 200,000,000 cu ft by the addition to its system of a new 2000-hp station near Charco, Texas; addition of 2200 hp to an existing station at Thomaston, Texas; 16 miles of 16-in. loop line near Provident City, Texas; some additional smaller lines and a 75-hp field compressor station. Cost of the new facilities is approximately $2,900,000.

On July 13, 1956, Texas Eastern and New York State Natural Gas Corporation jointly filed with the Federal Power Commission an application for construction that would bring about more efficient utilization of the Oakford Storage pool in western Pennsylvania. Included in the construction are the addition of 6000 compressor hp at the existing Jeannette compressor station, the removal from the Jeannette compressor station of 350 hp to be installed at a proposed South Oakford station, 3.5 miles of 20-in. pipe line extending from the Jeannette compressor station to a point on Texas Eastern's 30-in. line just north of the Delmont compressor station, 43 measuring stations, and the connection of three wells to the Oakford Storage project piping system. The cost of the project is estimated at approximately $2,100,000.

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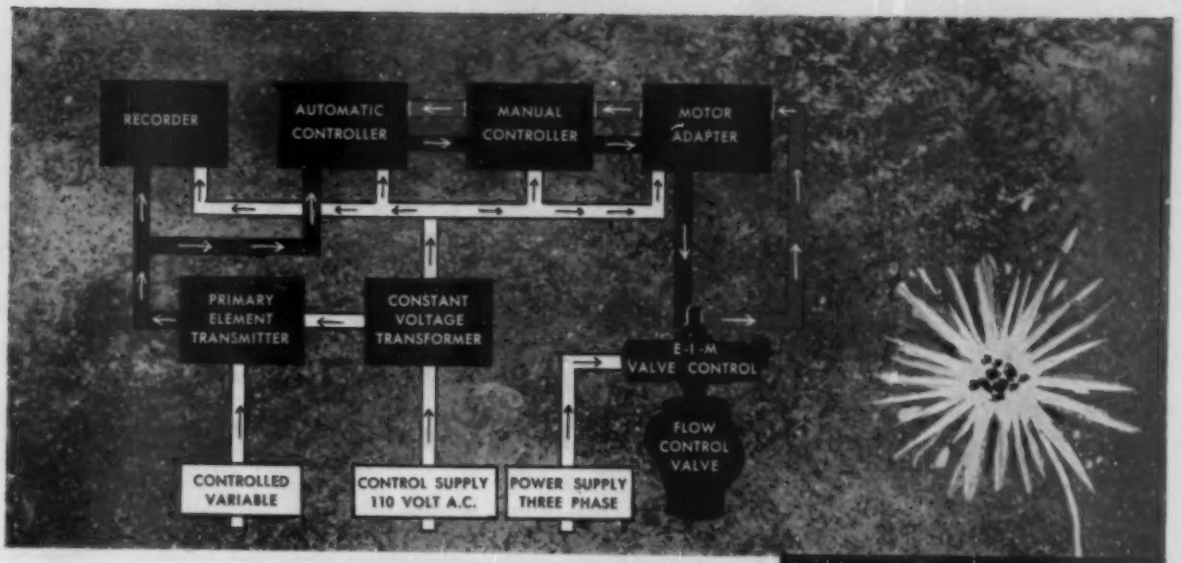

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Construction Report

TGT Adds 700 Miles in '56

Muskrat Line Builders Had To Conquer Lower Louisiana's Watery World

N the lonely, watery world of Southeast Louisiana, 1956 may be recalled as the year when the anguished squeal of the pipe line "pig" smothered the bellow of the bull alligator.

Or, as the year when mortified pelicans hid out, startled into a shameful sense of inferiority by the spacious "beaks" of pipelining draglines.

For, during 1956, barge-riding natural gas pipeliners splashed through Louisiana's great marshlands and swamps, leaving behind a concrete-coated spiderweb of steel.

They called it the "Muskrat Line."

Actually, this colorful nomenclature is a bit misleading, despite the geographical-zoological accuracy it embraces. For the "Muskrat Line" is not a single pipe line, but a network of pipe lines with an aggregate length of approximately 350 miles — a major extension of the Tennessee Gas Transmission Company's natural gas gathering system.

With its 24-in. "backbone" line and 4 to 20-in. feeders, which not only tap onshore wells but also finger into Gulf of Mexico leaseholds, this newly-extended gathering system provides a major market outlet for highly productive Louisiana areas.

The "Muskrat Line" was part of $56,000,000 construction program initiated by Tennessee Gas last spring. Other portions of that program include construction of 216 miles of line parallel to the company's main multiple-line system in Kentucky and Ohio and the addition of compressor horsepower at new and existing stations in Louisiana and Mississippi.

Subsequently, under a temporary certificate granted by the Federal Power Commission in July, the company began construction of an additional $20,000,000 in facilities to serve customer companies' added needs dur-

Map showing route of Tennessee Gas Transmission Company's Muskrat Line.

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FIG. 1931—for suction service on large capacity gravity lines and low-pressure large-volume transfer service. Capacities, 291 to 838 GPM at pressures from 225 to 125 PSI.

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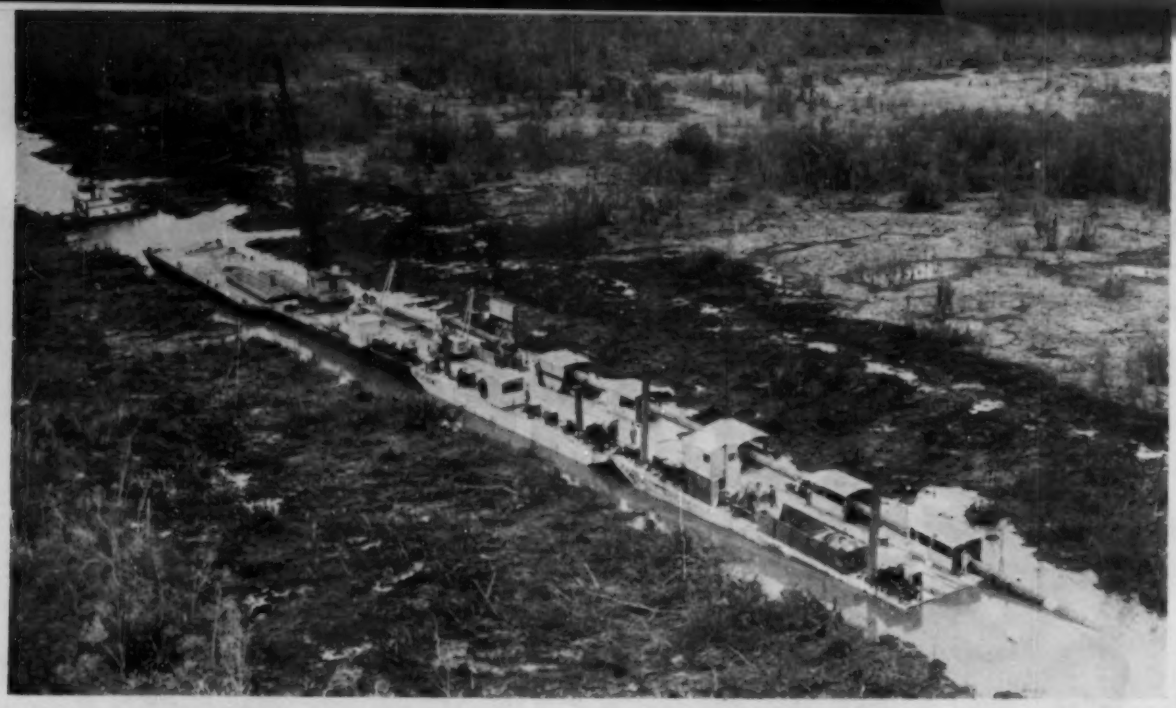


Houston Contracting Company barge lays pipe for TGT's Muskrat Line in a specially-dredged 40-ft wide canal through the Southeast Louisiana marshlands.

Barges equipped with facilities for welding pipe together and for coating the welded joints were used in construction of the Muskrat Line. Individual lengths of pipe were coated with concrete before being delivered to the laying barges.

ing the coming winter. These facilities include 162 miles of loop line in Kentucky, Ohio, and Pennsylvania and additional compressor horsepower in Massachusetts, Mississippi, Tennessee, and Louisiana.

Tennessee Gas, with headquarters in Houston, operates more than 9000 miles of natural gas pipe line in 15 states. Its system begins in deep South Texas and stretches approximately 2200 miles into northern New England.

Mostly Underwater

The "Muskrat Line" was one of the most unusual pipe line projects in the company's 12 years of operation. Nearly four-fifths of this gathering system extension lies underwater.

Beginning just west of Crowley, Louisiana, it extends eastward through the Louisiana lowlands to the Mississippi River delta and onto the Gulf of Mexico. Taking the western tip near Crowley as the starting point, the first 70 miles of the "Muskrat Line" involved normal dry land construction. But from there on eastward the right-of-way becomes a waterway.

In addition to the crossing miles and miles of marshland which could not support standard pipelining equipment, the "Muskrat Line" crosses 130 navigable streams, lakes, bays, and canals, plus a multitude of smaller bodies of water. But its right-of-way encounters only four roads and two railroads.

Further complications came from the great depth of some of the rivers and channels crossed — for example, 100 ft at the Mississippi River, 80 ft at Pass A'Loutre, 60 ft at the Atchafalaya River, 52 ft at the Wax Lake outlet channel and 40 ft in South and Southwest Passes. Crossing widths ranged from just a few feet at smaller streams to seven and one-half miles at Lake Raccourci, seven miles at Caminada Bay and six miles at Lake Barre.

By Air and by Sea

From the beginning, travel by air was common. Helicopters equipped with pontoons were used by the survey crews. These useful craft not only furnished transportation but also actually pulled the 1000-ft measurement chains from stake to stake through the marshes. Other amphibious aircraft were used also, shuttling engineers, inspectors and other personnel from place to place, eliminating the hours necessary for surface travel.

Pipe line crews soon developed sea legs, living on quarterboats and commuting by water to the barges from which the pipe was laid.

Through the marshlands, dredges

Barge loaded with pipe and tied up to one of the pipe-laying barges provides landing place for one of the helicopters used during construction of the Muskrat Line. Travel was restricted to air and water along most of the right-of-way.

Workmen aboard Williams Brothers Company barge give concrete coating to a welded joint just before pipe is allowed to slide into its underwater ditch. This scene is on Lake Barre in Southeast Louisiana.

preceded the lay barges, excavating flotation canals 40 ft wide and 8 ft deep, then cutting a 4-ft trench in the bottoms of these canals for the pipe line.

The lay barges were equipped with cranes, sideboom "cats," launching ramps, and facilities for welding and coating, wrapping and concreting welded field joints.

The pipe, yard-coated with concrete, was delivered to job sites by barge from Morgan City, Larose, New Orleans, and Harvey.

Continuous Barging

On some of the lay barges the pipe was double-jointed before being tied into the line. On others, it was stove-piped length by length directly into the string. On all, the final step was the concrete coating of the welded field joints. Coating materials were mixed in batch plants near the ends of the barges. The concrete was poured into forms, which were covered and strapped in order to protect the fresh concrete as the pipe entered the water.

While the pipe was coated to keep it anchored underwater, as well as to protect it, measures had to be taken to make sure the heavy mainline and feeder valves stayed above the high tide mark. This was accomplished by erecting valve platforms atop pilings that were driven as deep as 40 ft. Some of these platforms are supported by as many as 30 pilings.

At its western end, near Crowley, the "Muskrat" system ties in with TGT's Bayou Sale gathering line which, in turn, is connected with the company's compressor station at Kinder, Louisiana. The Kinder compressor station is on the route of a 30-in. pipe line that runs along the Texas Gulf Coast into Louisiana, Mississippi, and Tennessee, connecting with the company's main multiple-line system at Portland, Tennessee, north of Nashville.

Contractors on the job included Houston Contracting Company, Grayco Constructors, Inc., Williams Brothers Company, Collins Construction Company, and Sharman, Allen, Gay & Taylor (formerly Associated Pipe Line Contractors, Inc.).

Over-all Construction Program

The construction program of which the "Muskrat Line" was a part is designed to increase the company's average-day system delivery capacity from 1,730,000 MCF to 1,800,000 MCF and peak-day capacity to 2,180,000 MCF.

Other phases of this $56,000,000 program, with completion expected this fall, include:

(1) Construction of 74 miles of 30-in. loop line from near Cave City, Kentucky, to Danville, Kentucky.

(2) Construction of 142 miles of 26-in. loop line in Ohio. One section is 81 miles long, from just north of the Ohio River near New Boston to near McConnelsville. The other, 61 miles long, runs from near Newcomerstown to near Lisbon.

(3) Construction of new compressor stations near Winnsboro, Louisiana, and New Albany, Mississippi, and a horsepower addition to the Kinder, Louisiana, station.

The $20,000,000 construction program certified by the FPC in July includes:

(1) Construction of 63 miles of 30-in. main line loop in Kentucky — from near Scottsville to near Cave City; in the vicinity of Danville; and east and west of Morehead.

(2) Construction of 99 miles of 26-in. main line loop in Ohio, Pennsylvania, and Kentucky — from near Greenup, Kentucky, to just north of the Ohio River; from near McConnelsville, Ohio, to near Newcomerstown, Ohio; and from near Lisbon, Ohio, to near Mercer, Pennsylvania.

(3) Construction of new compressor stations at Agawam, Massachusetts, and Savannah, Tennessee, and horsepower additions to the Kinder, Louisiana, and New Albany, Mississippi, compressor stations.

Completion of these facilities will increase the company's average-day system delivery capacity to 1,862,000 MCF and peak-day capacity to 2,315,000 MCF.

In addition to the above two programs, Tennessee Gas is also increasing the compressor horsepower of its stations at Isola, Mississippi, Albany, Ohio, and Campbellsville, Winchester, Catlettsburg, and Greenup, Kentucky, under previous certifications by the FPC. ★ ★ ★

TRADE PERSONALS

▸ **Jack D. Head** has been appointed assistant general counsel for Texas Eastern Transmission Corporation, Shreveport, Louisiana. Head, a partner in the law firm of Vinson, Elkins, Weems and Searls, assumes his new duties immediately. He will supervise the activities of the legal department of the company and participate along with other counsel in matters before the Federal Power Commission and the courts.

▸ **W. E. Roads, E. G. Baker,** and **George R. Ewing,** all of Service Pipe Line Company, recently have become new members of The Pipe Liners Club of Tulsa. Other new members are: **John W. Hawkins,** Mid-Continent Pipe Line Company; **William A. Elliott, C. M. Foos, George L. Pogson, B. H. Powers,** and **Robert F. Ezzell,** all of Great Lakes Pipe Line Company; **Lloyd Kirk,** Mohawk Petroleum Company; **John E. Himmelrich,** Pittsburgh Coke & Chemical Company; **Breen Ringland,** Shand and Jurs Company, and **Jay C. Butler,** Pipe Line Service Corporation.

▸ **W. T. Askew,** president of Sun Oil Company, Ltd., has been elected a member of the board of directors of Sun-Canadian Pipe Line Company, Ltd. Also announced was the election of **John C. Agnew,** director and treasurer, as secretary, and the resignation of **John Blair Moffett** as secretary and a director.

Askew has been associated with the parent Sun Oil Company for 25 years. A graduate of the Texas A&M College in 1931, he began his career as a chemical engineer at Sun's Marcus Hook (Pennsylvania) refinery. This year he became the first resident president of Sun Oil Company, Ltd.

▸ **T. T. Hendrix** has been appointed assistant chief operator-deliveryman at Phoenix, Arizona, by Southern Pacific Pipe Lines, Inc.

▸ **Joseph A. Salerno** has been named to the newly created position of field representative at Wichita, Kansas, for the gas purchase section of Northern Natural Gas Company. Salerno has his headquarters in the Rule Building in Wichita. The appointment was announced by G. E. Stahl, manager of gas purchases for Northern.

In his new position, Salerno will be assigned to gas purchase activities in Kansas, Oklahoma, and Colorado. He has been with Northern for eight years, most recently as a field measurement man at Garden City, Kansas.

▸ **R. A. Harvey,** superintendent of the central division, products pipe lines, Shell Oil Company, pipe line department, will be on special assignment for the department during the next year. His office will be in Indianapolis.

R. K. Schulze, technical assistant to the manager of the pipe line department, will become acting superintendent of the central division. Schulze's office also will be in Indianapolis.

R. R. Marichal, recently transferred from the Pacific Coast, will act as technical assistant to the manager in Schultze's absence.

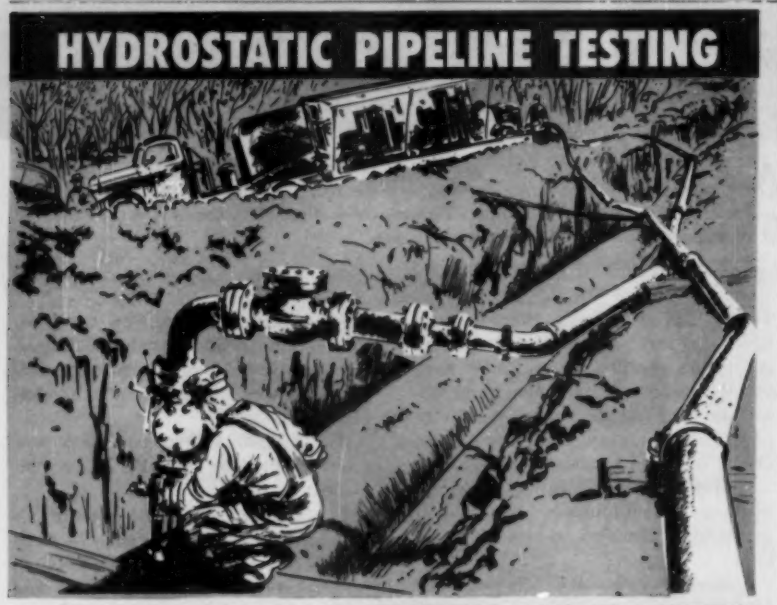
Harvey joined Shell Oil Company in 1940 as a chemical engineer in the transportation and supply section of products pipe lines, Zionsville, Indiana. Since then, he has served in various technical and supervisory capacities in East Chicago, Indiana, Wood River, Illinois, Toledo, Ohio, and, recently, Indianapolis.

Schultze joined Shell in 1937 as a junior safety engineer in St. Louis. In 1941 he was transferred to the head office, New York, and joined the transportation and supply section of products pipe lines in July, 1952.

Marichal joined Shell as an engineer-trainee in 1948, in Los Angeles. He served in various technical positions on the Pacific Coast until his transfer to the head office, New York, in June of this year.

▸ **Robert C. Ledford,** operations manager for Marine Gathering Company, Houston, Texas, has been elected vice president. Prior to joining Marine Gathering Company in 1950, he was construction superintendent of the McCarthy Chemical Company at Winnie, Texas.

▸ **C. D. Ozanich** has been appointed corrosion engineer of Southern Pacific Pipe Lines, Inc. He will be headquartered in Los Angeles, California.



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Trade Personals

▸ Reorganization of top management of Southern California Gas Company, Los Angeles, has been announced. **W. R. Davis** has been made executive vice president and **R. R. Blackburn** made senior vice president. Also announced was the election of **A. W. Strong,** now assistant vice president, to the position of vice president in charge of personnel, and of **C. A. Renz,** present manager of special services, to vice president responsible for special services and customers departments.

The reorganization has taken place because of the resignation of **W. M. Jacobs,** vice president and assistant general manager of the Southern California Gas Company. He has been elected vice president of the firm's parent company, Pacific Lighting Corporation. He has been associated with the Pacific Lighting System since 1931, when he joined Southern California as an industrial gas service engineer.

E. F. Hawkesworth, southwest division manager, has been named to replace Renz as manager of special services. **G. H. Pickett,** supervisor of special services staff, has been promoted to executive assistant. **R. B. Young,** supervisor of labor relations, has been promoted to the new post of manager of labor relations.

▸ **Alan R. Bailey** has been appointed senior vice president of Southern Counties Gas Company, Los Angeles. Formerly, he was assistant to the president of Pacific Gas & Electric Company, San Francisco.

▸ **Harry C. Jones,** Service Pipe Line Company division manager at Raytown, Missouri, has retired after more than 40 years of continuous service. Starting with the company in 1916, he has progressed through every level of field management.

▸ **George S. Colley, Jr.,** has been elected executive vice president and director of Pacific Bechtel Corporation, an affiliate of Bechtel Corporation. He has been with Bechtel 25 years.

M. E. Harper and **E. P. Kranzfelder** have been named to Pacific Bechtel vice presidencies. Harper has been associated with Bechtel for nearly 15 years. Kranzfelder formerly was in Korea as operations manager for three steam electric generating plants which Pacific Bechtel recently completed for the Republic of Korea.

▸ **R. K. Kelly,** manager of Tidewater Oil Company's eastern division marine department, has been named to head the division's newly organized transportation department.

He joined Tidewater in 1929 as marine superintendent. During World War II, Kelly was granted a leave of absence from Tidewater to serve in Washington as assistant director of supply and transportation with the Petroleum Administration for War.

▸ **Ray T. Scott,** division superintendent at Chicago for Standard Oil Company (Indiana) products pipe lines operations, has retired, having been with the company since 1921. **Spencer A. Hallberg** has been appointed to succeed Scott as Chicago division superintendent.

Hallberg started with Standard Oil in 1946 and has been Chicago superintendent pro-tem since late 1955, relieving Scott during convalescence after an automobile accident.

▸ **C. E. Schuyler** has been appointed superintendent of the Service Pipe Line Company, Shawnee, Oklahoma, to succeed **W. L. Hadley** who has retired after nearly 40 years service with the company.

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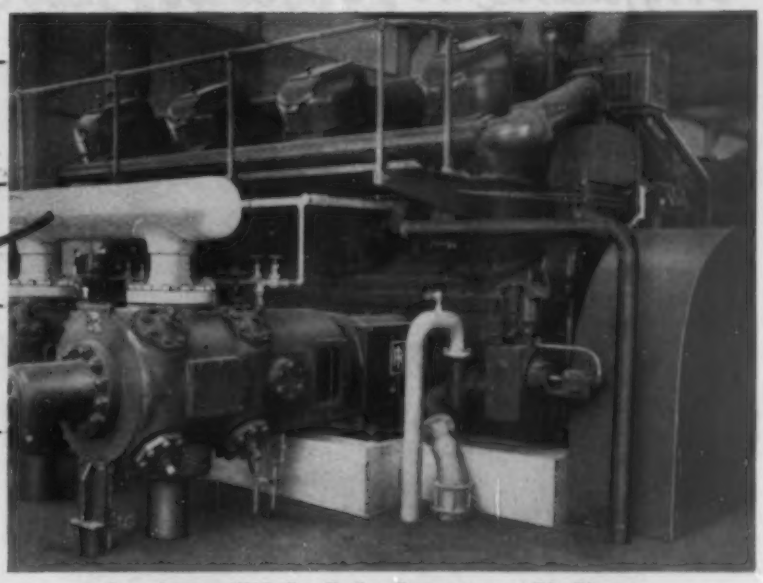

One of seven KVG Gas-Engine Compressors at Big Piney Station of Pacific Northwest Pipeline.

Seven KVG Units at 7,325 ft. altitude deliver gas from **BIG PINEY FIELD** to Pacific Northwest Pipeline

The Big Piney Station of the new Pacific Northwest Pipeline system is of special interest for two reasons.

Located at an elevation of 7,325 ft above sea level, it is the highest pipeline compressor station in the country—operating in temperatures ranging down to 40° below zero.

It has made possible the commercial utilization of Big Piney Field, which has been shut in for the past 18 years by lack of transportation facilities.

Hence it was quite appropriate that opening ceremonies for the Pacific Northwest Pipeline were held at Big Piney—where seven Ingersoll-Rand KVG Gas-Engine Compressors boost field gas to pipeline pressures. Two 880-hp units and two 660-hp units operate with intake pressures of 100-350 psi and discharge pressures of 400 to 550 psi. Three more 660-hp units have intake from 400 to 550 psi and discharge pressures of 650 to 850 psi.

Because of the extremely high altitude, the gas engines were supplied in bigger-than-normal sizes. Combined rated horsepower of the seven Big Piney units would be 5,060 hp at normal 1,000 ft altitude—for an actual load of about 3,885 hp under average conditions. The station is completely "winterized" for dependable operation at sub-zero temperatures.

Ingersoll-Rand Gas-engine Compressors now serving the various stations of the Pacific Northwest Pipeline include the following types and sizes:

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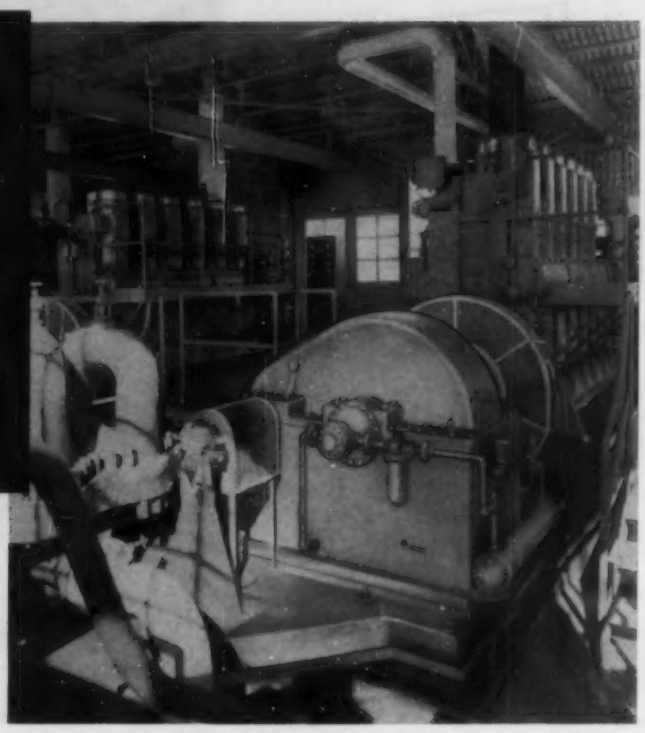

Ventura station has Western Gear Model 250 HS 90 High Speed unit, rated at 520 HP, driven by 520 HP Enterprise gas engine. Pump is 4-inch United centrifugal four-stage.

Four Western Gear high speed units were selected by Union Oil for installation in three pumping stations along its recently completed 100-mile pipeline system from the Santa Paula-Ventura fields to the refinery at Wilmington, California. The line now carries crude petroleum which formerly was transported by water in tankers.

The line travels over rugged country and one of the pumping stations was literally carved out of the side of a mountain. Another is completely automatic and unattended. All engines, gears and pumps are equipped with automatic temperature controls and temperature shutdown switches.

When designing and constructing pumping stations, progressive companies usually specify Western Gear speed reducers or high speed units. The unrivaled quality of Western Gear drives has made them the logical selection of the leaders in the petroleum industry. If you are planning on modernizing, replacing old equipment or building new lines, why not call on Western Gear for consultation on your gearing problems?

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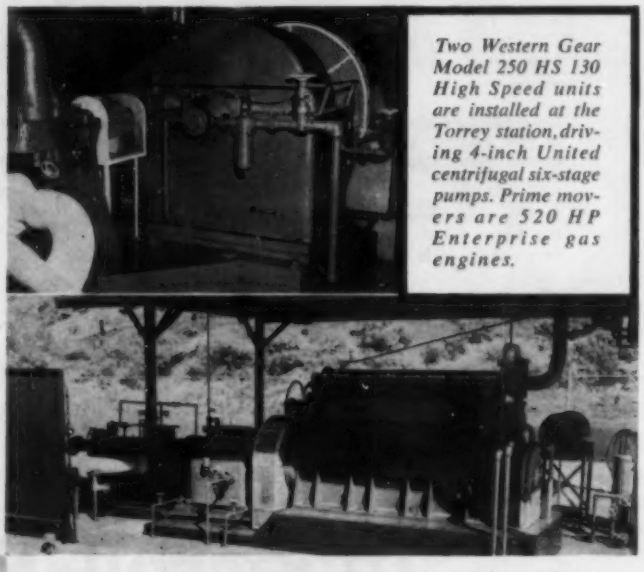

Two Western Gear Model 250 HS 130 High Speed units are installed at the Torrey station, driving 4-inch United centrifugal six-stage pumps. Prime movers are 520 HP Enterprise gas engines.

Western Gear 160 HS 90 High Speed unit, is installed at the Piru Union Oil Station. Unit is rated at 360 HP, prime mover is 300 HP Enterprise gas engine. Gear unit drives 4-inch United centrifugal two-stage pump.

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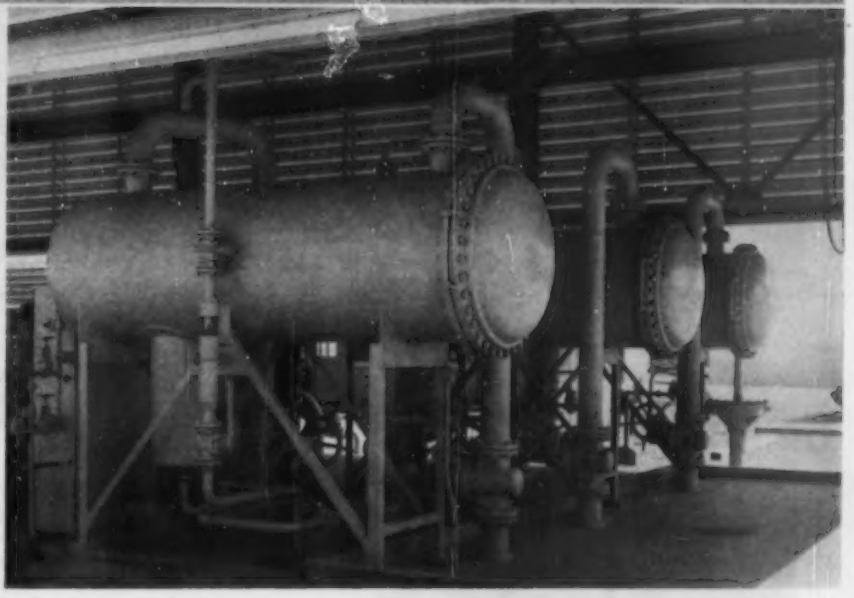

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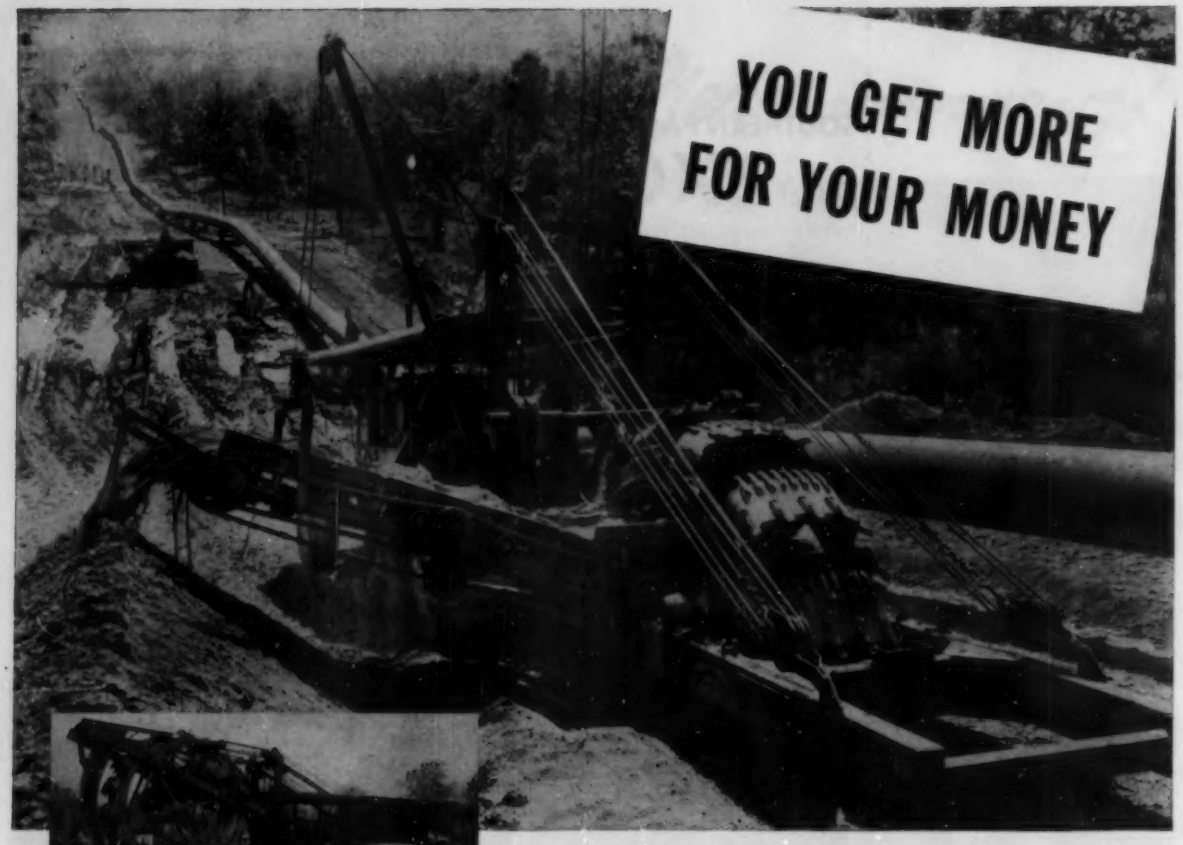


WORLD'S LARGEST DITCHER, the model 330, is another Gar Wood-Buckeye first! It digs 600 cubic yards per hour, cuts a ditch 11 feet, 3 inches deep and 64 inches wide. Yet, it is easily operated by one man. The 330 is typical of the years-ahead engineering that pipeliners have come to expect from Gar Wood-Buckeye.

WORLD'S MOST MODERN DITCHER, the Buckeye 308, reflects many of the engineering advances of the giant 330. Exclusive live hydraulic wheel hoist gives you faster, more accurate positioning of digging wheel . . . exclusive hydraulic conveyor drive provides three discharge speeds in either direction, adjusts instantly to handle any volume of spoil.

. . . in ditchers that bear the Buckeye brand!

Over the years, Buckeye ditchers have led the field in engineering advances. The world's first ditching machine, the first wheel-type ditcher, the first ladder-type ditcher . . . all have been Gar Wood-Buckeye developments. No wonder pipeliners who know equipment value have come to expect more for their money in ditchers that bear the Buckeye brand.

And — today's advanced Gar Wood-Buckeye machines are better than ever! Operation is faster, easier . . . operator control is positive and accurate . . . adjustments for changing digging conditions can be made in much less time. Maintenance is easier, too. There are more anti-friction and sealed-for-life bearings . . . many design improvements that make for faster field servicing.

In terms of ditch per dollar, in terms of day-in, day-out dependability, Gar Wood-Buckeye ditchers still lead the field. Ask your Gar Wood-Buckeye dealer to show you what modern ditcher performance can be. Or, write direct to: Customer Service Department, Gar Wood Industries, Inc., Wayne, Michigan.

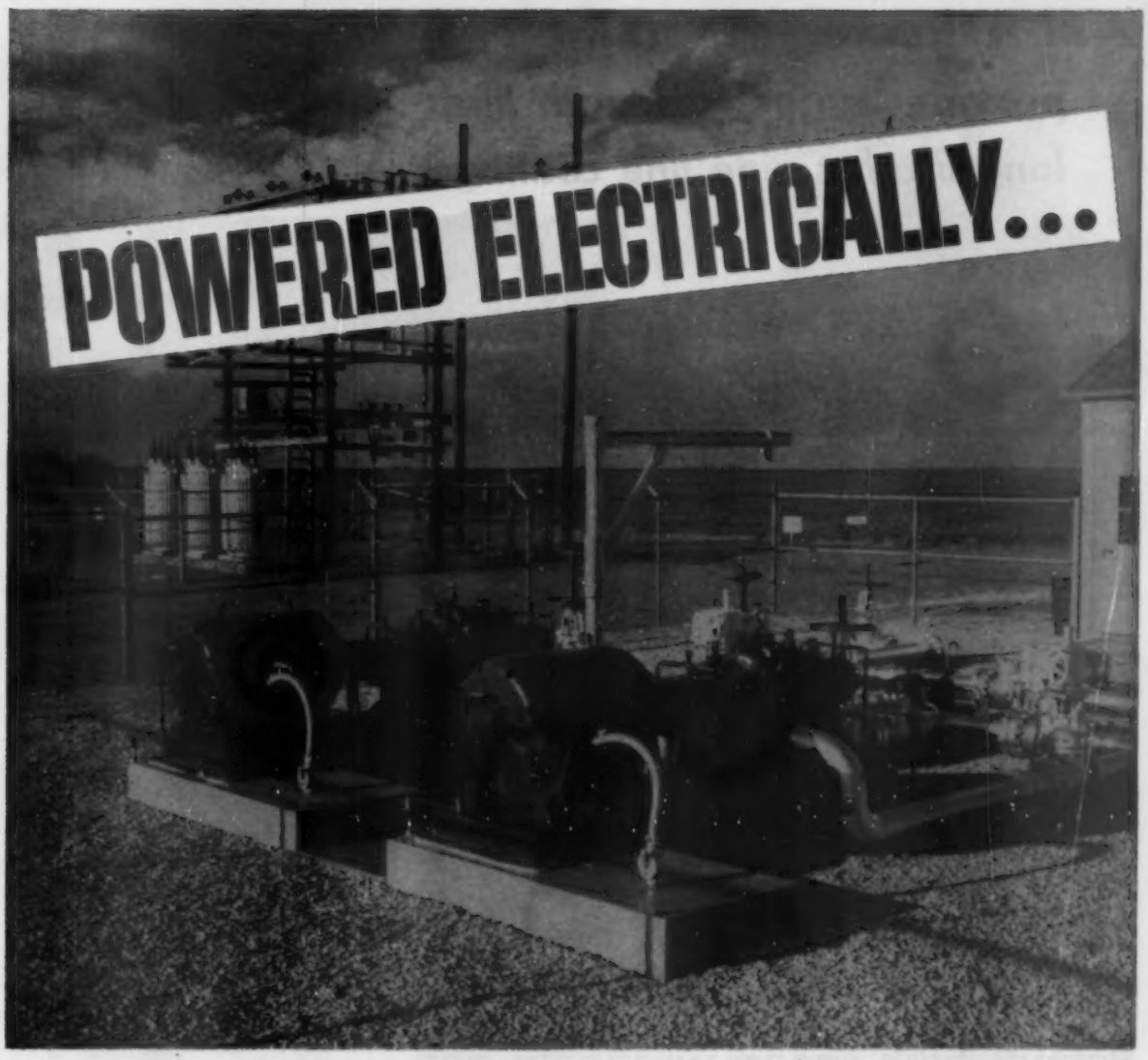
GAR WOOD INDUSTRIES, INC.

Wayne, Michigan • Findlay, Ohio

Plants in Wayne and Ypsilanti, Mich., Findlay, Ohio; Mattoon, Ill.; Richmond, Calif.

Gar Wood Buckeye

Gar Wood-St. Paul Hoists & Bodies | Gar Wood Winches | Gar Wood Tractor Equipment | Gar Wood Excavators



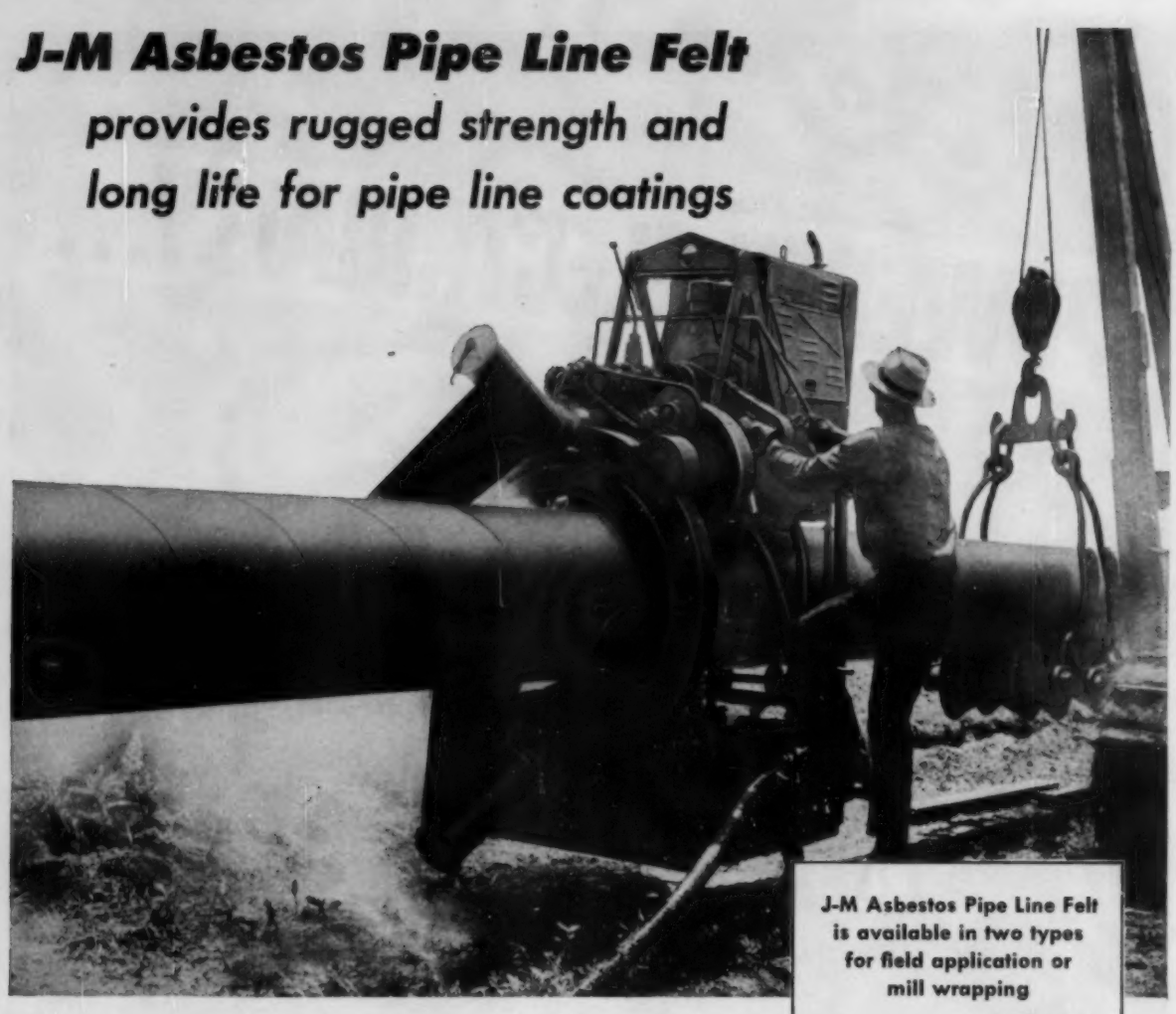
. . . There's a BIG DIFFERENCE!

Whenever Low Cost Utility Electric Power is on the job ... you'll readily see the difference. Electric Power offers the operator a cleaner power source with the added advantages of LESS MAINTENANCE, LESS ATTENTION, and LESS MANPOWER. Automatic Remote Controls also mean greater efficiency... plus a more economical operation. Be sure of power when and where you need it... but be sure its Low Cost Utility Electric Power.

WRITE PETROLEUM ELECTRIC POWER ASSOCIATION, P. O. BOX 2771, DALLAS, TEXAS, OR CALL THE SALES ENGINEER OF YOUR LOCAL UTILITY ELECTRIC POWER COMPANY — NOW

J-M Asbestos Pipe Line Felt

provides rugged strength and long life for pipe line coatings



Permits high-speed wrapping and effective protection for enamels

Johns-Manville Asbestos Felt gives pipe line coatings the rugged strength that is needed to guard the enamel from years of soil action. It forms a *stable* coating to reduce the hazards of pipe line corrosion leaks and provides a sound foundation when cathodic protection is used. Inorganic asbestos felt is the only wrapper that has survived more than half a century of actual service conditions in all types of soils.

J-M Asbestos Pipe Line Felt acts as a continuous sheath over the enamel . . . guarding the coating from the effect of the shifting grip of the soil as it expands and contracts due to alternate wetting and drying. It resists the destructive action of bacteria, fungi and soil chemicals, thus assuring long life to pipe line coatings.

J-M Asbestos Pipe Line Felt is available in two types for field application or mill wrapping

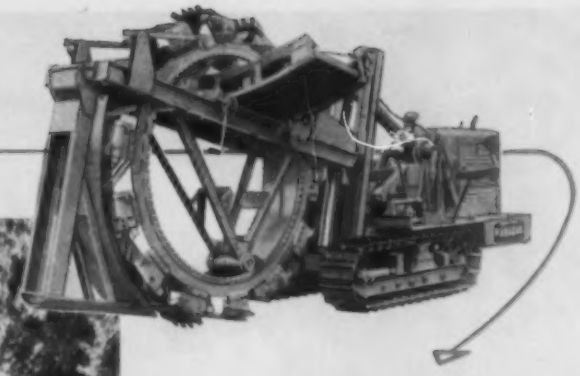
Transhield® Asbestos Pipe Line Felt—for average soil conditions.

#15 Asbestos Pipe Line Felt—heavy-duty material for severe soil conditions where a heavier material is desired.

For further information about Johns-Manville Products for Pipe Line Protection, write to Johns-Manville, Box 14, New York 16, N. Y., in Canada, Port Credit, Ontario.

Johns-Manville ASBESTOS FELT FOR PIPE LINE PROTECTION

Digs up to 1500 FEET per hour



Parsons 150 Trenchliner sets a fast pipeline pace on cross-country transmission lines, feeder lines, and gathering systems. For example:

30 digging speeds, from 12 inches to 25 lineal feet per minute, assure maximum trench production at every depth, width, and in all soil conditions.

6 trench widths range from 16 to 26 inches wide — and maximum digging depth is 5 feet 9 inches.

Holds accurate grade — Hydraulic ram on vertical mast raises and lowers the digging wheel, maintains close grade tolerance. (A separate ram tilts the mast, balances weight of wheel forward for traveling or trailer-loading.)

Cast-steel buckets, solid-type or tineback, have self-sharpening reversible "Tap-In" teeth or gumbo buckets to suit dry or wet digging conditions.

Dual-purpose friction clutch drives the digging wheel, and automatically protects machinery against shock loads.

Shiftable, reversible belt conveyor, 24 inches wide, discharges spoil to either side — 3 belt speeds on conveyor.

Standard tractor crawlers have 16-inch grouser-type shoes with replaceable links, bushings, pins. Ground-bearing pressure is low — only 6.3 lbs. PSI.

Choice of 2 standard engines — 60 h.p. gas or diesel. Better check how this 150 Trenchliner fits into your pipeline spread for main-line trenching — or as an auxiliary production unit for digging laterals.

Your Parsons distributor has more information that will interest you. See him, or write.

Send bulletin on Model 150. **PARSONS COMPANY,** NEWTON, IOWA

NAME _____ TITLE _____

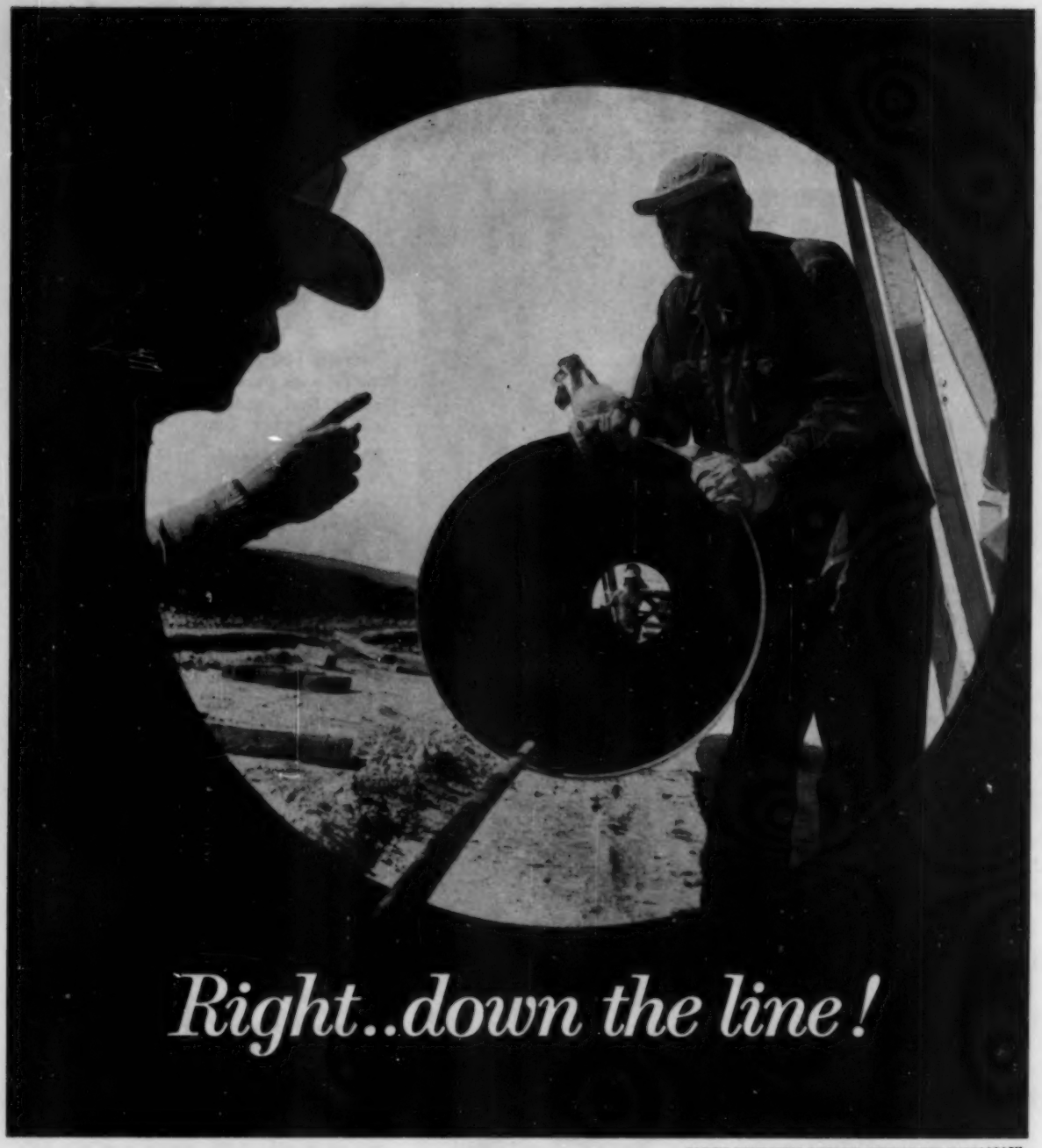
COMPANY _____ DIV. _____

STREET _____

CITY _____ STATE _____

6 other sizes of Trenchliners® in the Parsons heavy-duty line include wheel and ladder-type machines, full crawler mounted — and a small, utility-size Trenchmobile® on rubber tires.

(Koehring Subsidiary)



PACIFIC NORTHWEST PIPELINE CORPORATION PHOTOGRAPH.

Quality, uniformity, precision—these are watchwords that you can always depend on when you use Kaiser Steel Line Pipe.

For example, Kaiser Steel Line Pipe—20 inch OD and larger—is placed in restraining dies and expanded by water under great pressure. This hydraulic expansion assures accurate diameter, concentricity and straightness—and also strengthens the pipe through additional cold working. Another example of the painstaking care that goes into the manufacture of pipe from Kaiser Steel.

Next time you are ordering line pipe, specify Kaiser Steel Line Pipe. Rely on Kaiser Steel quality and service to add dollars to your operating profits.

Kaiser Steel

Steel Mill Products: plates • hot rolled strip and sheet • cold rolled strip and sheet • tin plate • continuous weld pipe • electric weld pipe • alloy and carbon bars • bar shapes • structural shapes semi-finished steels • pig iron • ingot molds • coke by-products • **Fabricating Division:** steel fabrication for construction, aircraft, missile and other industries • expanded fusion weld pipe reinforced concrete pipe • tanks • For specifications, write: **KAISER STEEL CORPORATION** • Los Angeles • Oakland • Seattle • Portland • Phoenix • Denver • Tulsa • New York

Take advantage of

25 YEARS EXPERIENCE

MANUFACTURING

FORGED ALLOY STEEL

Teeth that really dig

TOOTH COMPANY

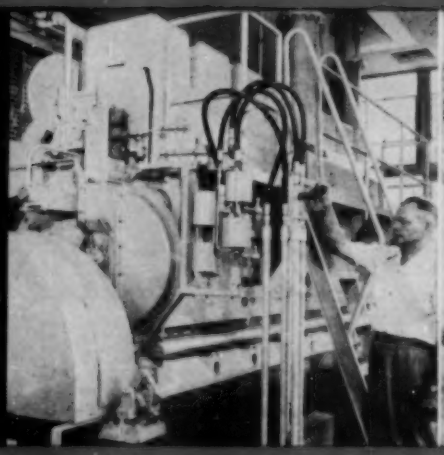
1540 SOUTH GREENWOOD AVE. MONTEBELLO, CALIFORNIA

NORDBERG ENGINES

Provide Low Pipe Line Transportation Costs ACROSS the Continent

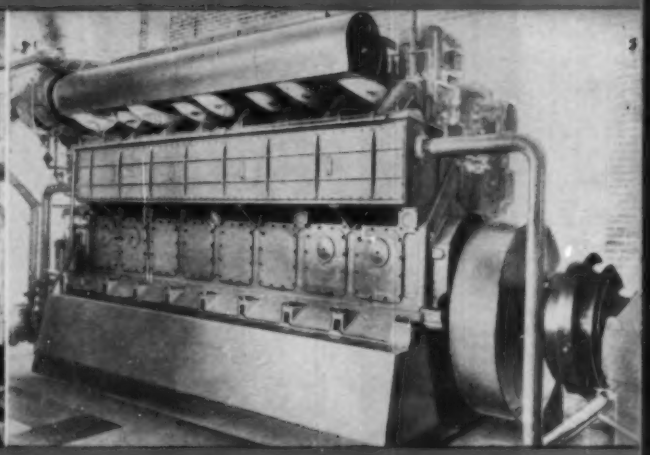
• Each year there are more and more Nordberg engines installed by pipe lines. The reasons are sound . . . these compact, more powerful engines efficiently meet the operator's requirements for all types of pumping.

NORDBERG POWER ON THE JOB:



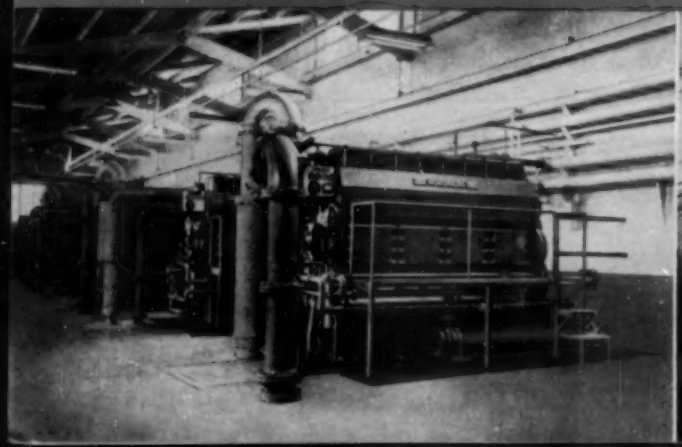
• One of two Nordberg eight cylinder, 1210 hp Supercharged Diesels on Shell Oil Company's Wood River products pipe line.

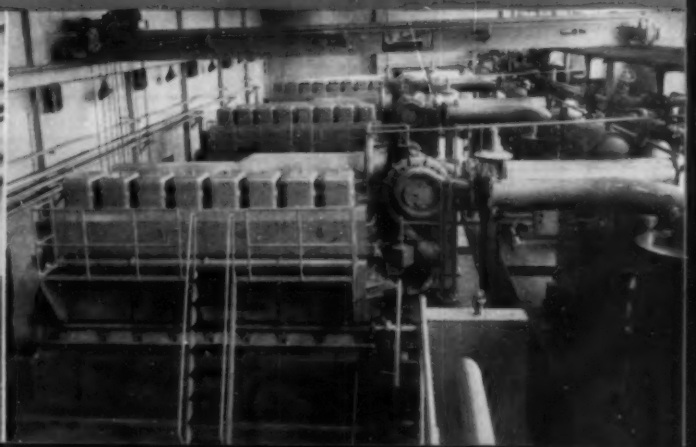
• Four of the 23 Nordberg engines installed in stations along the Rangeley, Colo.-Salt Lake City crude and products lines operated by Salt Lake Pipe Line Company.

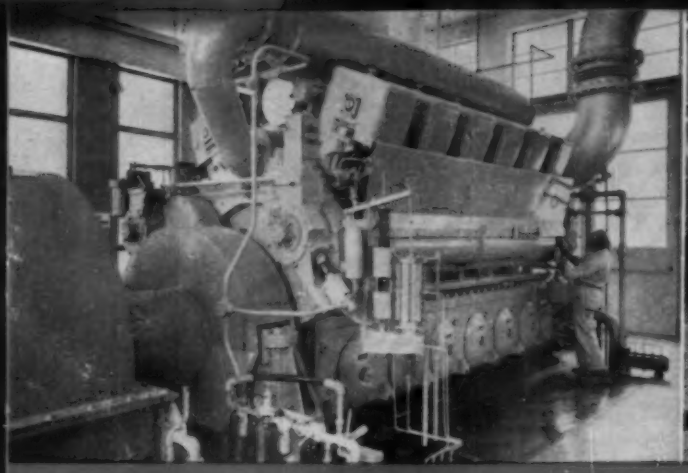


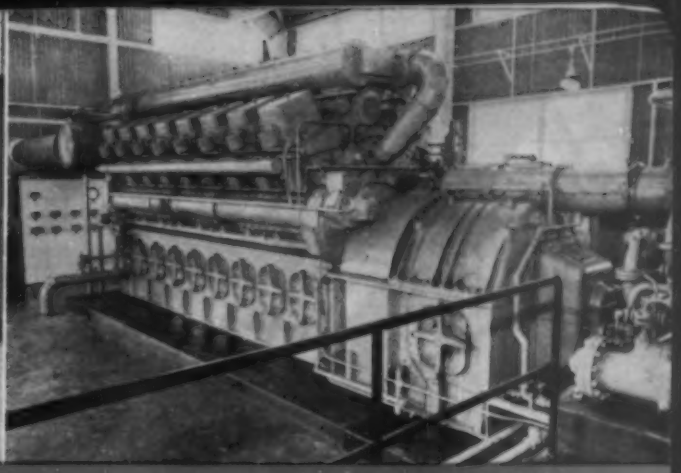
• One of nine Nordberg eight cylinder, 13" bore SUPAIR-THERMAL® Dualfuel engines operating on a Phillips Pipe Line Company products line.

• Twelve of these Nordberg SUPAIRTHERMAL engines provide a total of 22,680 hp for pumping stations along the Lakehead Pipe Line Company's line.







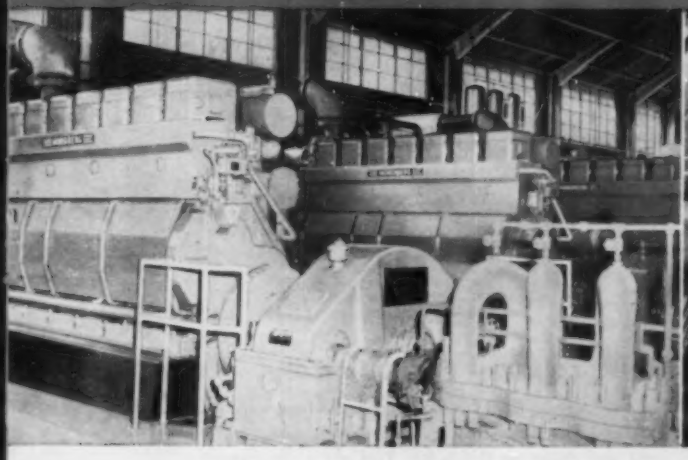


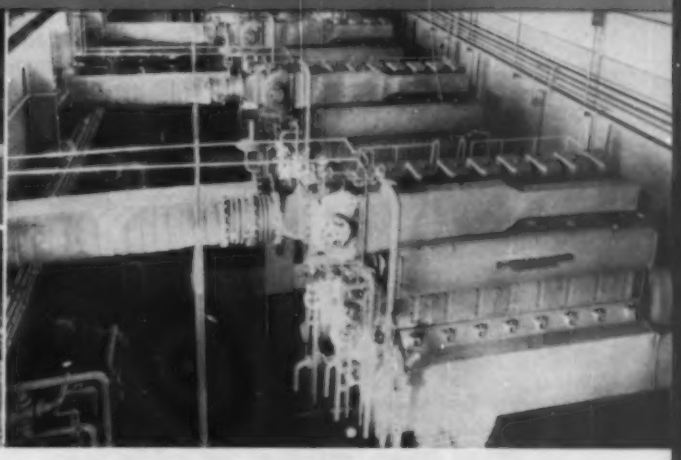
• Nordberg 2650 hp automatically-controlled SUPAIRTHERMAL V-type Diesel furnishes all power for the Vicksburg, Mich., station on the Wolverine Pipe Line Company's products line.

• Three of six Nordberg 1050 hp Duafuel engines installed in the Tejon and Wheeler Ridge stations of Richfield Oil Corporation's crude oil pipe line.

• 3000 hp Nordberg V-type SUPAIRTHERMAL Spark-Ignition Engine Gear Set driving a centrifugal gas compressor in Transcontinental Gas Pipe Line Corporation's Station 23 near Houston, Texas.

• Three of 12 Nordberg SUPAIRTHERMAL engines, totalling, over 20,000 hp, installed along the Trans Mountain Pipe Line from Edmonton, Alta., to Vancouver, B.C.





SUPAIRTHERMAL® ENGINES

the logical choice for these basic power jobs:

- **PIPE LINE PUMPING**
- **GAS COMPRESSOR DRIVE**
- **POWER GENERATION**

Nordberg four-cycle Supairthermal engines are available in a full range of sizes from 535 to 5000 hp for Diesel, Duafuel® or Spark-Ignition Gas operation, including both In-line and "V" types. The Supairthermal principle increases the engine's load-carrying ability over a wide speed range. This reserve power is like "money in the bank" when additional capacity is needed. We welcome your inquiry and the opportunity to assist you with your power study.

NORDBERG MFG. CO., Milwaukee, Wis.

Builders of America's Largest Line of Heavy Duty Engines—10 to over 12,000 Horsepower

NORDBERG

DIESEL • DUAFUEL® AND SPARK-IGNITION GAS ENGINES

© 1956, Nordberg Mfg. Co.

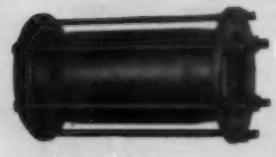
8256

EMERGENCY STOCK WAREHOUSES need these...

TO SPEED AND SIMPLIFY PIPE LINE MAINTENANCE

It always pays to stock Dresser Repair Equipment up and down the line to save valuable time in making repairs. Furnished for pressures as high as 1000 lbs. or more, these products make short work of dozens of maintenance problems. Buy them direct or from our Houston or South San Francisco Warehouses. Write today for catalog.

Style 38



Style 40

DEPENDABLE CONNECTIONS

For fast connections and repairs, use time-proved Dresser Couplings and Long Sleeves. Ideal for replacing damaged sections of pipe and for tie-ins. Quick and easy assembly—permanently tight. Complete size range.

Style 93

Style 96

FOR BREAKS, SPLITS, HOLES

Dresser Split Repair Sleeves are a quick, efficient means of repairing breaks, splits, holes and other failures in pipe lines. Easy to install. No loose parts —no welding. Self-sealing end-gasket pressure increases as line pressure increases. Sizes 6″ through 24″.

Style 55

TO REPAIR POROUS WELDS

Dresser Porous Weld Clamp stops leaks fast, without shutting down the line. Simply put it around the weld and draw up the bolts. You get a permanent repair in a matter of minutes. Sizes 2″ through 31″.

Style 110

Style 111

REINFORCING SLEEVES

Now available from Dresser in the best grade flange-quality steel plate. Uniformly perfect shaping assures easy installation. Vented against pressure build-up. Order Dresser Welding Sleeves for welded lines, Weld-over Sleeve for coupled lines. Can be furnished in special sizes and shapes when production quantities are involved.

DRESSER® ONE OF THE DRESSER INDUSTRIES

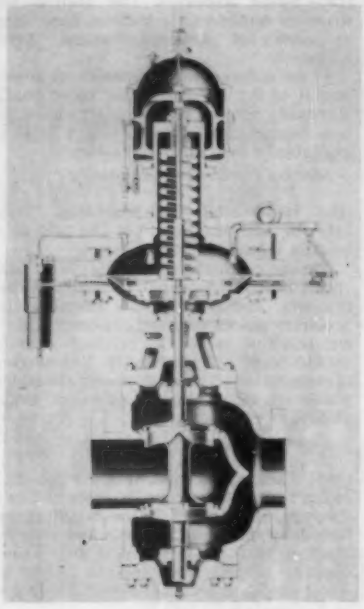
Dresser Manufacturing Division, 49 Fisher Ave., Bradford, Pa. Warehouses: 1121 Rothwell St., Houston; 101 S. Airport Blvd., S. San Francisco. In Canada: 1211 Bathhurst St., Toronto; 1210 11th Ave., W., Calgary.

NEW Pipe Line Equipment

• machinery • supplies • services

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

(81) Stable High-Pressure Regulator. To solve the problem of vertical instability or "jumping" that is sometimes encountered on high-pressure gas transmission lines,



Fisher Governor has introduced a high-pressure regulator.

Featured in the Series 883 and 885 regulators is an oil dash-pot which is claimed to dampen out any tendency of the valve to jump, yet will not cause valve to deviate from control point.

Rugged throughout, diaphragm casings are capable of withstanding 1000 psi. This new series is available in valve body sizes 2-in. through 12-in.

Fisher Governor Company.

(82) Pipe-Welding Electrode. Lincoln Electric has announced a new E-6010 electrode, Fleetweld 5-P, especially designed for pipe welding.

The Fleetweld 5-P is said to provide minimum slag interference, resulting in quick freezing of the molten metal and less tendency for "windows" and porosity. The electrode produces a flat-shaped bead in an even deposit from which slag is easily removed.

The Lincoln Electric Company.

(83) "Packaged" lubricating oil system center. Processes employing compressors and steam turbine drives can benefit from a "packaged" lubricating oil system center developed by Allis-Chalmers.

Shipped completely assembled, the units are mounted on a common base. A compact arrangement for oil reservoir, pumps, motor, turbine, coolers, and filters permits increased accessibility to gages and maintenance points.

Allis-Chalmers Manufacturing Company.

(84) Displacement-Type Level Controller. A displacement-type liquid level controller, announced by Kieley & Mueller, is claimed to have eliminated both bearings and knife edges, providing an extremely trouble-free controller for all services.

Called the Flexotrol Liquid Level Controller, the new design introduces a torque table which replaces pivoting members.

Controllers are available with external displacer chambers or in models for direct displacer immersion in the process vessel. As an optional feature, direct mechanical liquid level indication can be provided as a check on the pneumatic system.

Kieley & Mueller, Inc.

(85) Portable Rotary Compressor. Ingersoll-Rand announces the addition of an 85 cfm size to its line of Gyro-Flo compressors.

With this addition, the Gyro-Flo line of portable compressors has been increased to six sizes — 85 cfm through 900.

The Gyro-Flo 85 weighs only 1840 lb fully equipped with tool boxes, fenders and two-wheel, spring-mounted running gear. The light weight and compactness of this compressor also make it suitable for truck mounting. As a truck-mounted unit, the Gyro-Flo 85 weighs only 1375 lb and stands only 42 in. high.

Ingersoll-Rand Company.

(86) Ultrasonic Thickness Measurement. An ultrasonic thickness-measuring instrument, the SO-100 Sonizon, has been announced by Magnaflux.

Unit is portable, weighing only 30 lb, at least 20 lighter than previous resonance-type equipment. Its small case, light weight, and long (five-foot) search cable make it adapted for use in constricted areas.

Magnaflux Corporation.

(87) Wedge-Lock Pipe Plug. T. D. Williamson is manufacturing a device that can be inserted and securely locked into

the open end of a pipe line or piping to withstand high pressures.

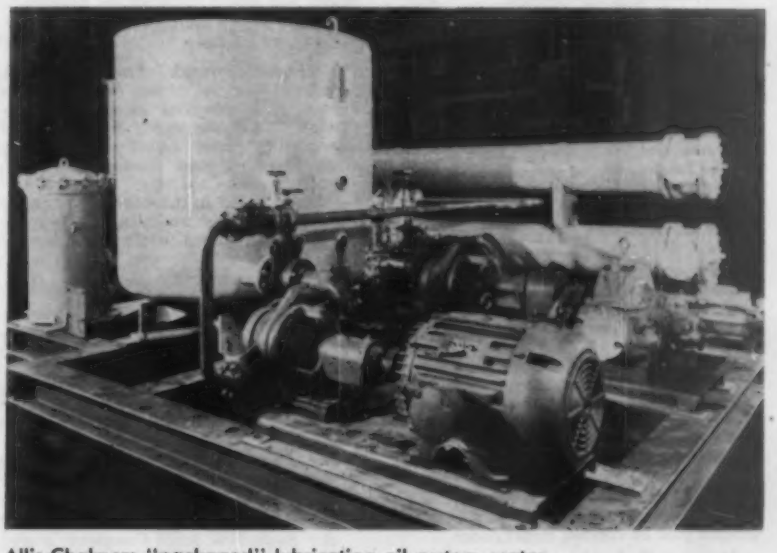
This plugging device, known as the Wedge-Lock Pipe Plug, is used to pressure-up piping and vessels for hydrostatic or air testing and to propel pigs by compressed air. Also it is utilized to plug open pipe ends to permit welding without hazard of flammable vapors.

T. D. Williamson, Inc.

(88) Pilot Starter. Start Pilot, a permanently installed device which provides quick starting for all gasoline and diesel engines, comes to the U.S.A. after more than eight successful years of use in Europe.

Pilot injects a small quantity of ignition-promoting fluid as a fine spray, into the engine intake manifold. Unit uses a special low-ether content blend of Sure Fire Motor Starting Fluid packed in hermetically sealed capsules which can be stored indefinitely without deterioration.

Wilco Company.



Allis-Chalmers "packaged" lubricating oil system center.

NEW Literature

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

(89) Excavators. A catalog describing a 25-ton lift, ¾-cu yd dipper capacity 305 excavator has been released by Koehring.

The eight-page, two-color, illustrated catalog gives concise descriptions of the Model 305 when equipped as a shovel, crane, hoe or dragline. Unit is available either crawler mounted or on a truck chassis. It carries a rated lift capacity of 25 tons on rubber, 15 tons on crawlers, and can be equipped with a full complim:nt of attachments.

Koehring Company.

(90) Heavy-Duty Trucks. International Harvester now is offering a 20-page catalog which contains complete information on International four-wheel conventional and cab-over-engine heavy-duty trucks with six-cylinder engines.

Gasoline, liquefied petroleum gas, and diesel-powered models are covered. Full-color and two-color illustrative treatment is employed throughout the booklets.

International Harvester Company.

(91) Tractor Shovels. Frank G. Hough has released a bulletin on its line of Payloader Tractor Shovels.

Bulletin describes and illustrates a wide variety of industrial materials-handling applications for these tractor-shovels, including case histories of "Payloader' operation in a number of plants.

The Frank G. Hough Company.

(92) Pump and Compressor Troubles. Two booklets have been issued by Worthington, one on diagnosing pump troubles and the other on compressor troubles.

The pump booklet tells how to locate and correct common ailments of rotary, centrifugal, and steam pumps. The compressor booklet indicates how to located and correct common air-cooled and water-cooled compressor troubles. Cartoon sequence pictures illustrate both booklets.

Worthington Corporation.

(93) Protective Paint Coatings. Publication of a paint manual, Tygon Protective Coatings Bulletin, is announced by U. S. Stoneware. Manual is designed for use as a practical work book, presenting useful painting data in the form of charts, tables, diagrams and illustrations. Virtually all factors relating to the use of Tygon Protective Coatings in mild to severe corrosive service are covered in detail.

The U. S. Stoneware Company.

(94) Power Pipe Pushing. What is said to be the first complete and authoritative booklet describing the techniques of power pipe pushing has been issued by Mercury Hydraulics.

This manual, titled "Power Pipe Pushing," is used in conjunction with the "Speed-Thru" hydraulic pipe pusher, but it is universally applicable. The described and illustrated methods shown can be used in connection, in most cases, with any type of pipe pusher, whether hand or power operated, and will prove extremely valuable to anyone concerned with underground pipe or conduit installations.

Mercury Hydraulics, Inc.

(95) Plastic-Coated Raceways. A booklet called "Installation Guide for Plastic-Coated Raceways" has been issued by General Electric.

It contains step-by-step illustrated installation details recommended for obtaining maximum protection and efficiency from plastic-coated, rigid steel conduit and electrical metallic tubing.

General Electric Company.

(96) Air-Cooled Selenium Rectifiers. A two--page, color information sheet on CSI Air-Cooled Selenium Rectifiers for cathodic protection against corrosion has been issued by Corrosion Services. Rectifiers are especially designed for the advantages of down-opening door, better ventilation, accessibility of parts, and rear cable openings.

Corrosion Services, Inc.

(97) Coupling Selector. A coupling selection chart developed and issued by Morse Chain is said to reduce the time necessary to select a flexible coupling to a matter of minutes. The chart, 22 in. by 17 in., may be hung on the wall, inserted under a glass desk top, or folded for easy filing.

Morse Chain Company.

(98) Twin-Power Scraper. Euclid Division of General Motors has released literature describing its Model TS-18 Twin-Power Scraper.

This catalog explains the twin-power principle, pioneered by Euclid in the off-the-highway field in which there are two engines of 218 hp each, one in the tractor and one behind the scraper bowl, each driving an axle through a separate Torqmatic Drive.

Euclid Division, General Motors Corporation.

(99) Piping Engineering. A simplified analysis of single-plane piping systems is explained in a 20-page booklet prepared by the research staff of Tube Turns. Diagrams and charts illustrate the booklet.

Tube Turns, a division of National Cylinder Gas Company.

(100) Diesel-Powered Tractor Shovel. Structural features of the Allis-Chalmers HR-6G diesel-powered tractor shovel are discussed, and the shovel hydraulic system of this tractor shovel reviewed, in a two-color, eight-page catalog now available from Allis-Chalmers.

Also included in the illustrated catalog are specifications and listing of interchangeable matched attachments for the HD-6G.

Allis-Chalmers Manufacturing Company.

(101) Metallic Powder Cutting Equipment. A four-page folder has been published by Air Reduction Sales Company, covering its complete line of metallic powder cutting equipment for cutting and washing stainless steels, other high alloy steels and cast iron.

Both vibratory and pneumatic-type powder feeders, along with hand and machine torches, are illustrated and described.

Air Reduction Sales Company, a division of Air Reduction Company, Inc.

(102) Hydraulic Backhoe. A six-page, three-color bulletin illustrates special features of new TerraTrac hydraulic backhoe, with detailed operational drawings, and complete specifications for both backhoe and TerraTrac crawler tractors on which it can be mounted.

This backhoe, first of its kind to be designed, built, and fully warranted by a crawler tractor manufacturer, for heavy-duty crawler use, is said to offer 12 exclusive features.

American Tractor Corporation.

(103) Speed Reducers. The Metron Instrument announces a bulletin describing its small but powerful Bantam Speed Reducers.

These reducers have a maximum power output of 0.1 hp at the low speed shaft. Standard units and units with an anti-backlash feature are described. Each kind is available in over 400 fixed ratios.

Metron Instrument Company.

(104) Repowering Old Machines. "New Life for Old Machines" is the title of a booklet issued by Caterpillar.

Theme of this booklet deals with machines powered by engines such as cranes, crushers, and cotton gins. Perhaps, the brochure points out, the customer's present machine is not as productive as it should be or was previously. Repowering in many cases gives the customer the added advantage of increased equipment availability.

Caterpillar Tractor Company.

(105) Excavator-Crane. The "Pipeliner," Insley's excavator-crane, is described in a six-page, illustrated color brochure released by the company. Specifications include a 30 to 45-ft boom with a lifting capacity ranging from 2600 to 20,000 lb. Total weight as a backhoe is 40,380 lb and as a clamshell 37,500 lb.

Insley Manufacturing Corporation.

(106) Hydrometers. A two color, eight-page illustrated bulletin on its complete line of hydrometers and thermo-hydrometers for use when accurate indications of specific gravity or other density scale are required, has been issued by Precision Thermometer and Instrument.

The Princo line hydrometers and thermo-hydrometers have individually calibrated handmade scales and conform with the requirements of the National Bureau of Standards for certification.

Precision Thermometer and Instrument Company.

(107) Bolted Steel Tanks. A 16-page brochure on bolted steel tanks has been published by Columbian Steel Tank. Brochure features a pictorial description of the use and application of synthetic gasket materials in the erection of bolted steel tanks.

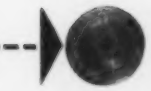
Columbian Steel Tank Company.

(108) Analog Computer. Reeves Instrument announces a 16-page brochure illustrating and describing the advanced design features of the 400 Series REAC ® Analog Computer.

Brochure details the many new "firsts" incorporated in this computer design. The modular "building block" construction of the 400 Series is described, and a special section is devoted to the completely redesigned high stability d-c amplifiers used in the computer.

Reeves Instrument Corporation, a subsidiary of Dynamics Corporation of America.

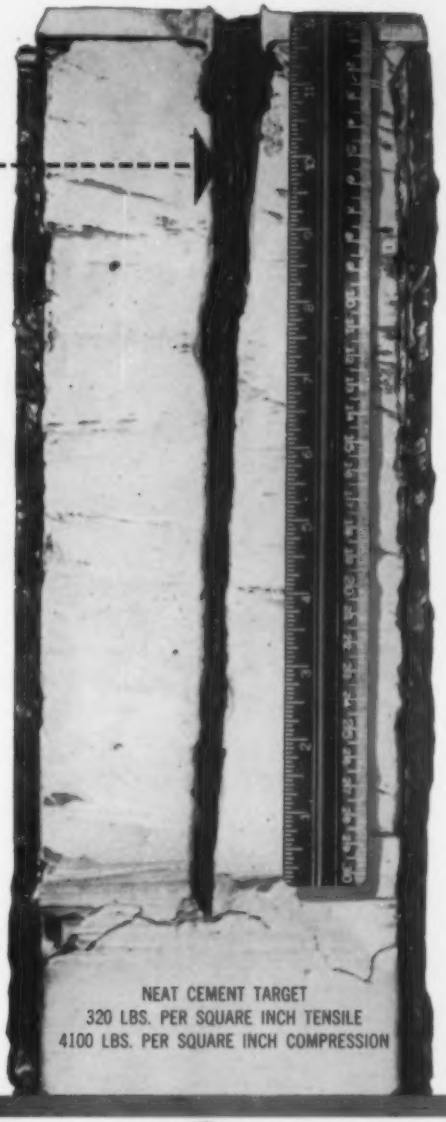
All you see is the "keyhole"



⅛" HOLE IN FLUID SEAL
⅝" HOLE IN STEEL PLATE

1" DIAMETER HOLE
IN TARGET

but look at the "hallway" it blasts!



NEAT CEMENT TARGET
320 LBS. PER SQUARE INCH TENSILE
4100 LBS. PER SQUARE INCH COMPRESSION

with "Karrotfree" Koneshot

Just as the size of a room has no relation to that of the keyhole in its door, you can't judge the depth or diameter of a "KARROTFREE" Koneshot perforation by the tiny hole you see in the screw port when the gun comes out of the hole.

The photograph on the right shows what you really get with Lane-Wells exclusive "KARROTFREE" Koneshot Perforating. The screw port shown is the actual one which protected the "POWER-PAK" shaped charge which punched that hole through ⅜" steel plate and nearly 12" into 16-day neat cement. "KARROTFREE" Koneshot was *planned* to do just that – to punch a tiny hole in the screw port, thus trapping formation-plugging carrot and charge debris, and drive deep into the formation for maximum penetration and optimum production. And only the Lane-Wells exclusive "POWER-PAK" shaped charges used in "KARROTFREE" Koneshot can give you this combination of deep penetration and debris-free hole!

Tomorrow's Tools – Today!

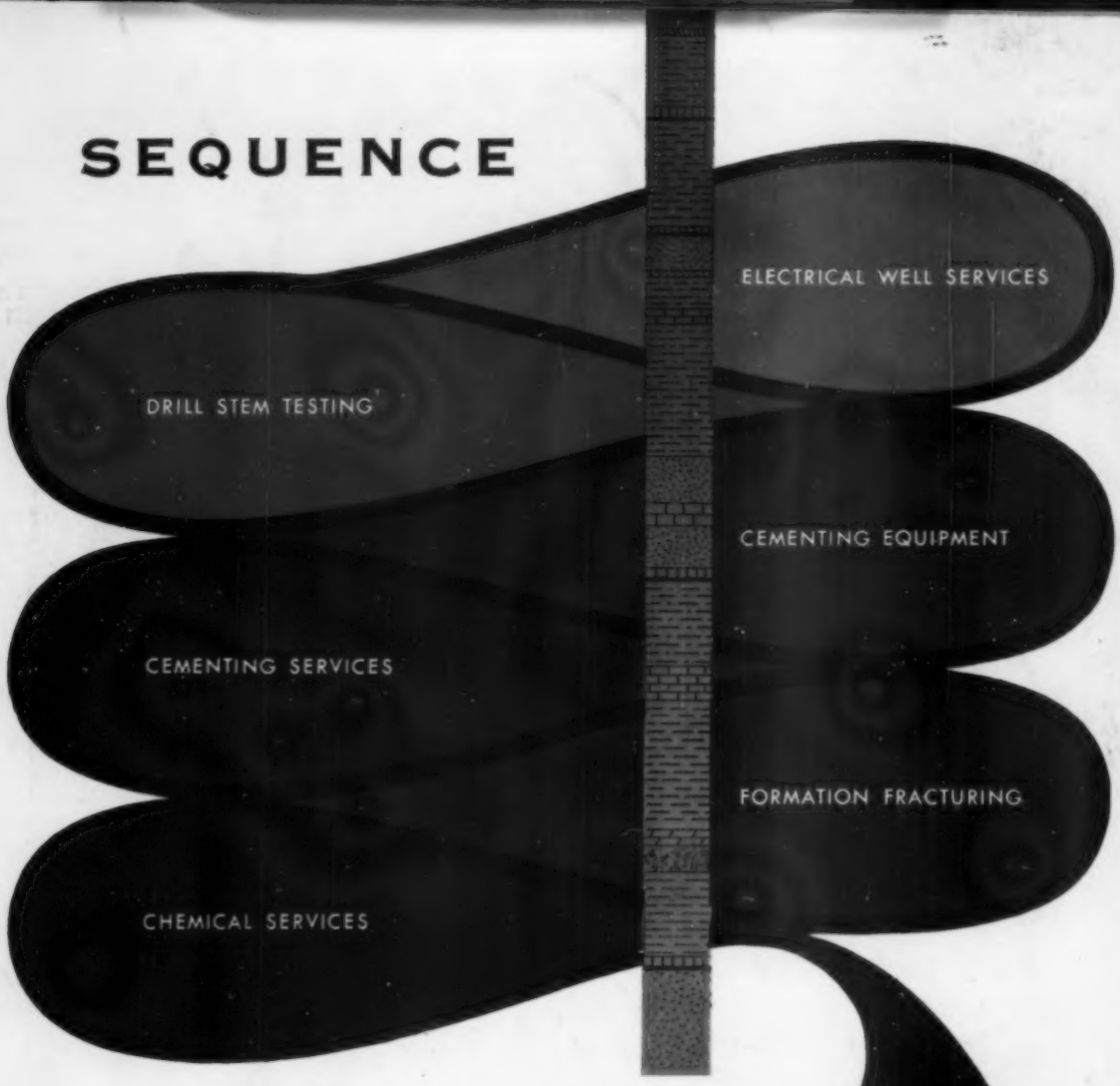
LANE WELLS COMPANY

Sales and Service Headquarters | 511 West Alabama Street, Houston, Texas
Mail Address: P.O. Box 1664, Houston 1, Texas

General Offices, Export Office and Plant
5610 So. Soto St., Los Angeles 58, California

LANE-WELLS CANADIAN CO. IN CANADA
PETRO-TECH SERVICE CO. IN VENEZUELA

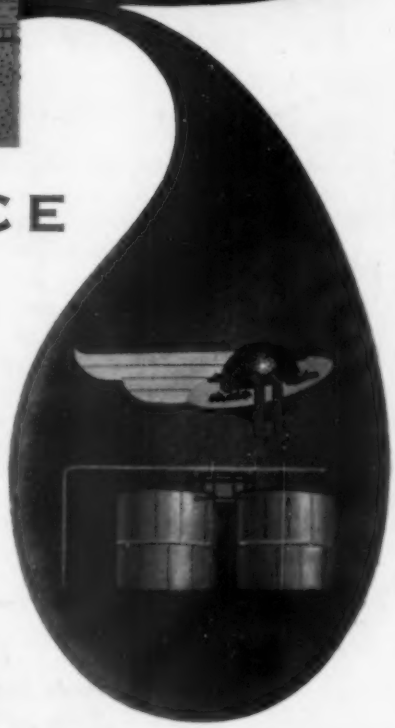
SEQUENCE



CONSEQUENCE

Out of the pipe comes the final answer... right or wrong. You've done your best to recover the maximum potential. You've brought into common action all the well completion services and production improvement techniques at your command. Your chances that the answer will lie on the right side of the balance sheet will be greatly improved if it's the *Halliburton sequence* of services you've used. A uniform, logical succession of interdependent techniques that let your well say which ... because there is no selfish emphasis on one service at the expense of others.

Each of these six services is backed by Halliburton's three-million-job experience... 33 years of research... and unique policy of performing service beyond the fee, service above all. And each makes an important contribution to putting more oil in your tanks... the most desirable possible consequence.



"Progress In Service Through Research"

HALLIBURTON
OIL WELL CEMENTING COMPANY
DUNCAN, OKLAHOMA